CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 70 OCTOBER 1984 NUMBER 4

California Fish and Game is a journal devoted to the conservation of wildlife. If its contents are reproduced elsewhere, the authors and the California Department of Fish and Game would appreciate being acknowledged.

Subscriptions may be obtained at the rate of $5 per year by placing an order with the California Department of Fish and Game, 1416 Ninth Street, Sacramento, California 95814. Money orders and checks should be made out to California Department of Fish and Game. Inquiries regarding paid subscriptions should be directed to the Editor.

Complimentary subscriptions are granted, on a limited basis, to libraries, scientific and educational institutions, conservation agencies, and on exchange. Complimentary subscriptions must be renewed annually by returning the postcard enclosed with each October issue.

Please direct correspondence to:

Perry L. Herrgesell, Ph.D., Editor
California Fish and Game
1416 Ninth Street
Sacramento, California 95814

CALIFORNIA FISH AND GAME

VOLUME 70 OCTOBER 1984 NUMBER 4

Published Quarterly by

STATE OF CALIFORNIA

THE RESOURCES AGENCY

DEPARTMENT OF FISH AND GAME

—*LDA*—

CONTENTS

Calif. Fish and Game 70(4): 196–209 1984

CHARACTERISTICS AND ATTITUDES OF SOME KLAMATH RIVER ANGLERS [1]

JEFFREY L. KERSHNER [2] and ROBERT R. VAN KIRK
Humboldt State University
Arcata, California 95521

Klamath River anglers were surveyed in the fall of 1979 to determine attitudes toward various aspects of a fishing experience. A questionnaire containing various items relating to personal characteristics and preference in an angling experience was administered to 257 anglers.

Seven factors or reasons for a fishing trip were identified involving sensory feelings, act of fishing, escape, water closeness, catching fish, food source, and fishing alone.

Results from the analysis of the identifying variables versus the factors indicated that anglers over 45 showed a preference for keeping fish for food and enjoyed the act of fishing. They showed little interest in being close to the water. People under 45 showed more interest in being near the water, but indicated little interest in the act of fishing and keeping fish as food.

Eighty-five percent of the anglers surveyed were males. Males showed a great deal of interest toward the act of fishing, being close to water, and fishing alone. Females indicated that nature-related aspects were the most important in a fishing experience.

Seventy-two percent of the anglers used spinning rods and reels, 23% used fly rods and fly reels, and 5% used open face casting reels and casting rods. Fly fishermen were interested in being close to the water while spin fishermen showed the most interest toward keeping fish as a food source.

Results from the regulation questions indicated users of spinning and conventional tackle did not support reduced bag limits while fly fishermen indicated support for reduced harvest. A "flies-only" designation to some waters of the Klamath was supported by fly fishermen, while spin fishermen reacted negatively to the proposal. Removal of jet boats from Weitchpec to Happy Camp was supported by 72% of all anglers.

INTRODUCTION

Fisheries managers have long been concerned with methods of increasing fish populations as the most effective way to satisfy the recreational fishermen. Recent studies have shown, however, that other factors may play a more important role in a successful sport fishing experience. Bryan (1974) found the "escapism-relaxation" and "out of doors" aspects of fishing were most important to salt water anglers. Moeller and Engelken (1972) found that elements of the natural environment such as water quality, natural beauty, and privacy while fishing were more important than size or numbers of fish caught to New York fishermen. Hampton and Lackey (1976) found that fishery managers' attitude, water quality, natural beauty, and companionship with family and friends were the most important concerns to pond anglers in Virginia.

The Klamath River is one of the major recreational fisheries in California. Coots (1952) estimated 100,296 angler hours were expended for steelhead, *Salmo gairdneri,* during a period from September 1949, to 31 August 1950. More recently (1980), anglers expended a total of 104,294 angler hours fishing on the

---

[1] Accepted for publication December 1983.

[2] Mr. Kershner's current address is: U. S. Forest Service, El Dorado National Forest, 100 Forni Road, Placerville, CA 95667

lower Klamath River alone (L. B. Boydstun, Sr. Fishery Biologist, California Department of Fish and Game, pers. commun.).

Identification of the factors most responsible for a successful fishing experience could aid resource managers in making decisions that will improve a Klamath River sport fishing experience.

A large river such as the Klamath presents some logistical problems in administering a questionnaire. Mail-in questionnaires allow a large group of people to be surveyed, but response rate can be disappointing (Phillips 1966). Duttweiler (1976) found that mail surveys provide access to a large group of anglers and felt that response rate was less of a problem if follow-up letters were sent to questionnaire recipients.

Direct census of a survey group such as anglers allows the researcher to personally contact the survey population; questions arising from the questionnaire can be clarified by the researcher and a higher response rate is usually achieved (Babbie 1973). However, each interview takes a relatively large amount of time and this may be a factor when a large group is surveyed (Phillips 1966).

A questionnaire was developed to identify angler attitudes and preferences of Klamath River fishermen. Objectives of the questionnaire were:

(i) To describe angler attitudes toward their fishing experience on the Klamath River;
(ii) To describe relationships between angler characteristics and angler attitudes;
(iii) To identify and evaluate current regulation issues concerning the fishery and measure angler response to those issues.

STUDY SITE

The Klamath River originates from Lake Ewauna in south central Oregon and flows southwesterly for approximately 421 km to the mouth at Requa, California.

The Klamath has a number of access points. U.S. Highway 101 crosses the Klamath north of Eureka at the town of Klamath River, California. Interstate 5 crosses the Klamath approximately 18 km above Yreka, California, where it provides access to California Highway 96. Highway 96 is the major access route to the river and follows the river from Interstate 5 to Weitchpec, California. Highway 96 can also be reached from California Highway 299 at Willow Creek, California.

The study section included the area from Weitchpec to Presidio Bar fishermen's access (Figure 1). Major sampling points included public camping areas and various fishermen's access points within the area.

MATERIALS AND METHODS

The Fisheries

The steelhead trout and chinook salmon, *Onchorynchus tschawytscha,* provide important sport fisheries on the Klamath River (Kesner 1969). Two separate runs of chinook salmon occur in the main river: a spring run fishery, which begins in March and lasts until mid-June (U.S. Fish and Wildlife Service 1960). Because spring flows are usually high and turbid, few people fish for these fish. A fall run

begins in early August and lasts until mid-October. Most effort is concentrated in the lower 10 km of the river. Salmon fishing in the study section is minimal and directed to a few specific locations.

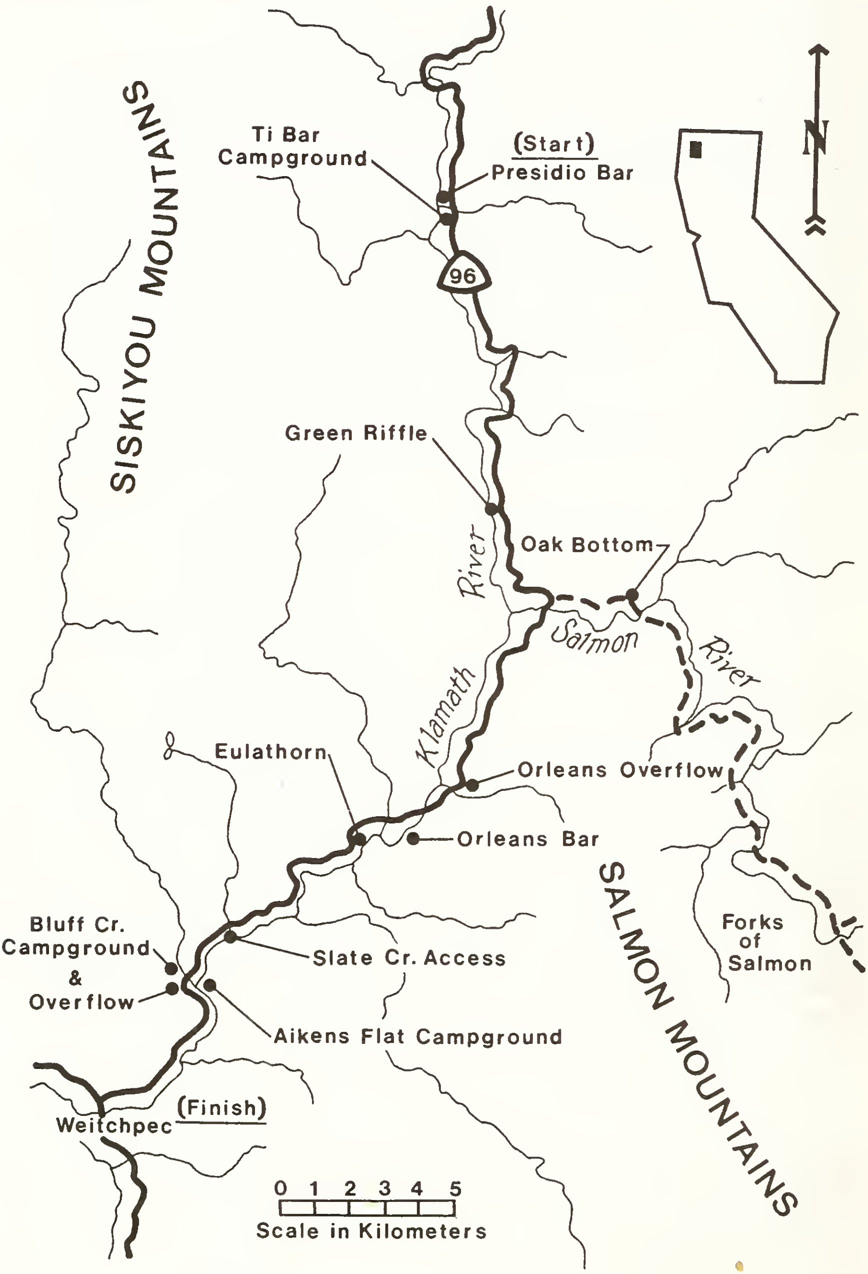

FIGURE 1. Map of the study area. Black dots and accompanying names are major sampling points.

The fall run steelhead is an important sport fish on the upper Klamath River above Weitchpec. Two distinct groups of fish compose the fall steelhead run. The "half-pounder" is a small, immature steelhead ranging from 250–349 mm. These fish spend from 1 to 3 years in fresh water before beginning their seaward migration. After a few months in salt water, they return to enter the river from the first part of August until the end of October (Kesner 1969). Arrival at the study area usually occurs near the end of August and is most prevalent from mid-September to early November (John Grondalski, Fishery Biologist, Calif. Dept. of Fish and Game, pers. commun.).

The second component of the steelhead fishery is the sexually maturing adult fish that ascend the river from mid-July to early November. Adult fish arrive at the study section in late August and continue until December. The greatest numbers of adult fish are found in the study area from mid-September until mid-November; after mid-November most adults have migrated farther upriver.

A pilot questionnaire was developed and administered to anglers in the fall of 1978 to gather demographic information and assess their reasons for coming to the Klamath River. In addition, questions concerning various regulations were also included. Results from this questionnaire were used to develop a series of questions related to the reasons for a fishing trip. These items were used to build a preliminary questionnaire which contained 25 items on various aspects of a fishing trip. The preliminary questionnaire was administered to a group of Humboldt State University students. Results were analyzed to determine the clarity of the questions and whether recognizable groups of factors could be identified.

The final questionnaire was developed in the early summer of 1979 (Table 1). Identification variables included age, sex, number of years fishing, and the type of fishing gear. Informational questions on the length of fishing trip, number of trips per year, and the amounts of money spent per trip were also included. Items dealing with the reasons why people fished were generated from the results of the pilot and preliminary questionnaires.

Questionnaire Administration

Questionnaires were administered two consecutive days a week from 21 September to 7 November 1979. Sampling on 28 October was discontinued due to heavy rains and poor fishing conditions. Sampling days were alternated consecutively each week to minimize the bias that might develop from weekend sampling (large numbers of short-trip fishermen) or weekday sampling (large numbers of fishermen who may be there for extended periods of time). For example, if the sampling days were Monday and Tuesday of one week, they would be Wednesday and Thursday the following week.

Sampling was conducted by driving to the start of the study section (Figure 1) and administering the questionnaire to available fishermen. Available fishermen were those anglers who were not actively fishing. This could include fishermen at their cars, walking to or from fishing sites, or in camp relaxing. Sampling was conducted from approximately 1000 h to 1700 h. This period coincided with the slack period of fishing when most anglers were available at camp or not actively fishing.

TABLE 1. Final Questionnaire Completed By 257 Anglers.

KLAMATH RIVER ANGLER QUESTIONNAIRE

In recent years, fisheries managers have begun to study the interests and needs of fishermen relating to their favorite waters. Information from these studies is used to develop "people oriented" management for our fishing waters. When combined with sound biological management, the two form a more effective management system. This questionnaire attempts to survey your reasons for going fishing. We would appreciate your cooperation in completing this form.

Do not write in this area.

Section I. General Information
(Please mark the appropriate response.)

Age ______   ___ 1   ___ 2

Sex (Circle One) 1. Male 2. Female   ___ 3

Number of years fishing (Check one)   ___ 4

1. 1–5 ( )
2. 6–10 ( )
3. 11–15 ( )
4. over 15 ( )

Length of present fishing trip ______ days   ___ 5   ___ 6

How much money do you spend on a trip on the Klamath? (Check one only)   ___ 7

1. Less than $25 ( )
2. $25–50 ( )
3. $50–100 ( )
4. $100–250 ( )
5. $250–500 ( )
6. over $500 ( )

How many trips do you make to the Klamath each year? (Check one)   ___ 8

1. 1–3 ( )
2. 4–6 ( )
3. 7–10 ( )
4. More than 10 ( )

What kind of tackle do you use most often? (Check one only)   ___ 9

1. Fly rod and fly reel ( )
2. Spinning rod and spinning reel ( )
3. Spinning rod and conventional reel ( )

Would you be willing to support the following regulations?   ___ 10   ___ 11   ___ 12

Yes	*No*	
1. ___	2. ___	Smaller bag limits.
1. ___	2. ___	Special flies only water on some areas of the Klamath.
1. ___	2. ___	Remove motor boats from Weitchpec to Happy Camp.

Section II.

The following statements may represent reasons why you go fishing. We ask you to identify your priorities. In other words, what do you want from your fishing experience? The response scale is divided into three categories. Choose the response that most accurately reflects your feeling on each statement. Please complete all items.

High	*Moderate*	*Low*
9 8 7	6 5 4	3 2 1

Fishing Experience	*Interest Level* *High*	*Moderate*	*Low*	*Do not write in this area*	
Fishing by myself	9 8 7	6 5 4	3 2 1	( )	13
Getting away from my day-to-day responsibilities	9 8 7	6 5 4	3 2 1	( )	14
Feeling the water rush past	9 8 7	6 5 4	3 2 1	( )	15
Comparing fish stories	9 8 7	6 5 4	3 2 1	( )	16
Enjoying the natural beauty around me	9 8 7	6 5 4	3 2 1	( )	17
Doing something besides my normal routine	9 8 7	6 5 4	3 2 1	( )	18
Concentrating on the movement of my line	9 8 7	6 5 4	3 2 1	( )	19
Watching the sun go down on clear water	9 8 7	6 5 4	3 2 1	( )	20
Getting my limit	9 8 7	6 5 4	3 2 1	( )	21
Fishing a nice piece of water alone	9 8 7	6 5 4	3 2 1	( )	22
Escaping the pressures of everyday life	9 8 7	6 5 4	3 2 1	( )	23
Feeling my lure working through the water	9 8 7	6 5 4	3 2 1	( )	24
Wading through heavy water	9 8 7	6 5 4	3 2 1	( )	25
Catching a few fish	9 8 7	6 5 4	3 2 1	( )	26
Casting with my favorite tackle	9 8 7	6 5 4	3 2 1	( )	27
Sitting around the campfire after fishing	9 8 7	6 5 4	3 2 1	( )	28
Observing a deer crossing the water	9 8 7	6 5 4	3 2 1	( )	29
Fishing with close friends	9 8 7	6 5 4	3 2 1	( )	30
Landing a big fish	9 8 7	6 5 4	3 2 1	( )	31
Standing in the river current	9 8 7	6 5 4	3 2 1	( )	32
Watching a steelhead jump	9 8 7	6 5 4	3 2 1	( )	33
Getting my tackle ready for a fishing trip	9 8 7	6 5 4	3 2 1	( )	34
Observing a good friend catching a steelhead	9 8 7	6 5 4	3 2 1	( )	35
Feeling the afternoon breeze on the water	9 8 7	6 5 4	3 2 1	( )	36
Eating the day's catch	9 8 7	6 5 4	3 2 1	( )	37

___ ___ ___
78 79 80

CARD ID

Questionnaires were given to all anglers encountered during the survey day. Anglers were asked to complete the questionnaire and return it promptly. Respondents were very cooperative; only two anglers declined to fill out the form. However, respondents did not always complete all questions on their questionnaire.

When all available fishermen in one area were sampled, the survey moved to the next access point downstream. This process continued until the start of the evening fishing. Surveying on the second day began at the last survey point of the previous day and continued downstream to the end of the study section.

Questionnaire Analysis

Responses to the 25 items dealing with "Fishing Experience" were factor analyzed. Principal components were extracted and then varimax rotated to the final solution. A one-way Analysis of Variance and a Multiple Classification Analysis were performed between the identifying variables and the factor structure to examine differences in subgroups. A cross-tabulation was performed on the I.D. variables age, gear used, and years fished versus the regulation questions concerning bag limits and "flies only" water. A raw chi-square test was performed on these data.

RESULTS

Two hundred fifty-seven anglers completed the final questionnaire. One questionnaire was found unusable and discarded.

The first objective of the questionnaire was to describe angler attitudes toward their fishing experience on the Klamath River. Responses to the 25 items dealing with "Fishing Experience" were factor analyzed using the techniques described in the "Materials and Methods" section. A seven factor structure was used to express the results (Table 2). These included factors relating to sensory feelings, act of fishing, escape, water closeness, catching fish as a food and fishing alone.

Factor 1 (Sensory Feelings) The seven items included under this factor relate to the natural surroundings and some associated feelings about them.

Factor 2 (Act of Fishing) describes the physical act of fishing and associated activities such as gear preparation, and casting.

Factor 3 (Escape) relates a willingness to do something other than the normal routine.

Factor 4 (Water Closeness) relates to the feelings of being in the water and feeling it around you. Mean scale scores differ from the other factors in that they show a somewhat negative response to this factor.

Factor 5 (Catching Fish) is related directly to the capture of fish.

Factor 6 (Food Source) indicates a desire to use fish for food.

Factor 7 (Fishing Alone) relates a desire to fish apart from others.

Item 4 in the questionnaire (comparing fish stories) did not relate to any of the seven factors.

Responses from the "length of fishing trip" question were split into six separate categories. By far the largest category was the 4-to-7 day trip length. Forty-

seven percent of the anglers sampled were in this group. Forty-one percent of the anglers sampled had extended stays from 1 week to 3 months, while only 12% of the fishermen were "short trip" visitors (a trip length of 1 to 3 days).

Responses concerning the expenditures on a fishing trip were tabulated. The largest group of respondents belong to Group 4 ($100–$250) and make up 34% of the total. Money spent on a trip to the Klamath River includes expenditures for food, gas, and tackle, en route to the river and while on the river.

The overwhelming response (92%) to the "number of trips taken yearly" belongs to the 1–3 trip category. Responses to the other categories of this question were negligible.

The second objective of the questionnaire was to describe relationships between angler characteristics (I.D. variables) and angler attitudes (factor structure). All identifying variables were analyzed and results are discussed where significant differences occurred.

Age

Average age of the fishermen was 49 years. Sixty-three percent of the total sample was over 46 years of age.

Significant differences occurred among age groups and their attitudes toward the act of fishing, water closeness, and food source factors. People under 45 showed little interest in the act of fishing while people over 45 showed significant interest in this area. This same age group breakdown occurred in Factor 4, where people under 45 reacted favorably to being in the water while people over 45 indicated little interest in this factor.

Factor 6 dealt with using fish as a food source. Fishermen in the 14 to 25 and 56 to 82 age classes responded positively, indicating a preference for keeping fish for food. Fishing for food was of minor importance to fishermen in age class 26 to 55.

Sex

Eighty-five percent of the respondents were male. Significant differences were observed in the attitudes of males and females toward some factors.

Females showed a positive response to Factor 1 (Sensory Feelings), indicating that this was an important aspect of their fishing experience. Overall, males showed a much less positive response to this factor, which indicates that this aspect was of minor importance to their experience.

Males and females reacted significantly different to Factor 2 (Act of Fishing). Males responded positively to this factor, indicating that the mechanical aspects of fishing were an important part of their experience. Female response was negative, indicating that this was less important to their fishing enjoyment.

Females responded negatively to Factor 4 (Water Closeness), indicating little interest in this aspect of a fishing experience. Reaction of males to this factor was age specific.

Factor 7 (Fishing Alone) was of low interest to female anglers. Male anglers responded positively to this factor, indicating it was important to their fishing experience.

TABLE 2. Factor Structure of Responses Relating to Fishing Experience in the Final Questionnaire.

Item	*Mean*	*Std. Dev.*	*Commun-ality*	*Factor Loadings* 1	2	3	4	5	6	7
FACTOR 1—SENSORY FEELINGS										
Enjoying the natural beauty around me.	8.31	1.11	0.558	0.651	0.061	0.308	−0.142	0.034	0.109	0.043
Watching the sun go down on clear water.	5.89	2.40	0.631	0.579	0.361	0.154	0.271	−0.241	0.071	0.080
Sitting around the campfire after fishing.	6.60	2.22	0.504	0.638	−0.015	0.094	0.035	0.147	0.255	0.020
Observing a deer crossing the water	6.42	2.36	0.605	0.735	0.061	−0.064	0.147	0.030	0.157	0.099
Watching a steelhead jump.	7.56	1.80	0.064	0.564	0.300	0.105	0.106	0.319	−0.264	0.052
Observing a good friend catching a steelhead	7.35	1.81	0.541	0.596	0.366	0.097	−0.073	0.131	−0.120	−0.077
Feeling the afternoon breeze on the water.	6.10	2.30	0.539	0.634	0.276	0.102	−0.005	−0.050	0.166	−0.144
FACTOR 2—ACT OF FISHING										
Concentrating on the movement of my line.	5.92	2.33	0.628	0.098	0.764	0.109	0.037	0.026	0.039	0.137
Feeling my lure work through the water.	5.63	2.44	0.715	0.105	0.733	0.153	0.077	0.137	0.340	−0.054
Casting with my favorite tackle.	6.27	2.24	0.681	0.121	0.671	0.073	0.098	0.370	−0.075	0.241
Getting my tackle ready for a fishing trip	5.29	2.40	0.546	0.259	0.595	0.015	0.295	0.155	0.072	0.095
FACTOR 3—ESCAPE										
Getting away from my day-to-day responsibilities.	6.87	2.59	0.805	0.012	0.027	0.884	0.057	0.061	0.068	0.101
Doing something besides my normal routine	7.24	2.09	0.672	0.240	0.217	0.730	−0.088	0.133	0.086	−0.039
Escaping the pressures of everyday life.	7.06	2.26	0.763	0.156	0.110	0.842	0.019	0.133	−0.006	0.016

FACTOR 4—WATER CLOSENESS										
Feeling the water rush past	4.99	2.66	0.669	0.286	0.130	0.350	<u>0.466</u>	−0.233	0.405	0.112
Wading through heavy water	3.38	2.23	0.781	0.014	0.126	−0.025	<u>0.867</u>	0.018	0.025	0.108
Standing in the river current	4.54	2.46	0.833	0.023	0.120	−0.022	<u>0.897</u>	0.088	−0.047	0.056
FACTOR 5—CATCHING FISH										
Catching a few fish	6.54	2.00	0.581	−0.017	0.117	0.128	−0.065	<u>0.727</u>	−0.006	0.132
Fishing with a few close friends	7.99	1.76	0.531	0.428	−0.037	0.055	0.131	<u>0.533</u>	0.193	−0.062
Landing a big fish	7.99	1.74	0.530	0.072	0.264	0.105	0.094	<u>0.652</u>	0.095	−0.028
FACTOR 6—FOOD SOURCE										
Getting my limit	5.07	2.78	0.665	0.040	0.185	0.091	−0.058	0.465	<u>0.633</u>	0.031
Eating the day's catch	5.32	2.89	0.655	0.298	0.061	0.008	−0.008	−0.002	<u>0.750</u>	−0.017
FACTOR 7—FISHING ALONE										
Fishing by myself	5.35	2.45	0.743	−0.013	0.093	−0.049	0.051	−0.025	−0.078	<u>0.850</u>
Fishing a nice piece of water alone	6.45	2.43	0.702	0.033	0.126	0.138	0.129	0.120	0.080	<u>0.793</u>
ITEMS THAT DID NOT LOAD ON ANY FACTOR										
Comparing fishing stories	4.79	2.70	0.415	0.111	0.349	0.269	0.236	0.108	0.369	−0.066

Gear Used

Seventy-two percent of the anglers were spin fishermen, 23% fly fishermen, and 5% used conventional tackle (open face casting reels with bait casting rods).

Significant differences were apparent in two factors when compared to the type of tackle used. Fly fishermen responded positively to wading in the water (Water Closeness), indicating this was important to their fishing experience. Spin fishermen and fishermen with conventional gear showed a negative response, indicating that this was unimportant to their experience.

The Food Source factor concerns keeping fish as a food item. Spin and conventional fishermen reacted positively to the Food Source factor (keeping fish), while fly fishermen indicatd this factor was of minor value.

Questions concerning regulations and regulation changes were generated in the formative stages of the study. Three main areas of interest were indicated: (i) changes in the bag limit; (ii) removal of jet boats; and (iii) special areas of the Klamath to be set aside as "flies only" water.

The question of smaller bag limits drew a negative response from 61% of the anglers. A chi-square test was performed on the variables age, years fished, and gear used versus the smaller bag limit variable. Systematic relationships occurred between the variables Age versus Bag Limits and Gear Used versus Bag Limits (Table 3). All age classes except the 25 to 35 group indicated a negative response toward decreased limits. Sixty percent of the 25 to 35 group indicated they would favor smaller limits. Users of spinning and conventional tackle indicated they would not favor smaller limits, while fly fishermen strongly supported smaller limits.

Respondents were asked if they would support special sections of "flies only" water on the Klamath River. Responses were divided between those not favoring special areas (51% or 120 anglers) and those favoring special areas (49% or 114 anglers). Significant relationships occurred between the variables Gear Used versus Fly Only water (Table 3). Fly fishermen were overwhelmingly in favor of the special designations while spin fishermen and conventional fishermen reacted negatively to this proposal.

The last regulation proposal involved removing motor boats from Weitchpec to Happy Camp. Seventy-two percent (177) of the respondents were in favor of removing jet boats while 28% (69) were opposed.

TABLE 3. Raw Chi-Square Values and Their Significance for Various Combinations of Variables.

Variable comparisons	*Raw Chi-square*	*Significance*
Age vs. fly only	5.92	0.314
Age vs. bag limit	12.48	0.029 °
Gear Used vs. years fished	4.90	0.557
Gear Used vs. bag limit	55.77	0.000 °
Years Fished vs. fly only	41.90	0.000 °
Years Fished vs. bag limit	2.72	0.437
Years Fished vs. fly only	3.21	0.361

° Significant at .01.

DISCUSSION

Sensory feelings toward the environment, escapism, being close to water, and solitude are by-products of a fishing experience; a fishing experience is a multidimensional activity. In fact, other researchers have reported that these peripheral factors may be the most important reasons for sport fishing.

Hampton and Lackey (1976) reported that a minimum expectation of catch is important to anglers. However, water quality, natural beauty, and companionship ranked above catching fish in the same survey of Virginia anglers.

Moeller and Engelken (1972) felt that factors other than those related to catch were equally important in a fishing experience. They recommended that the concept of fishery management be broadened to include environmental management as well.

Factors involving catching fish, using fish as a food source, and the act of fishing can be combined as a "fishing oriented" dimension of a fishing experience. This dimension represents the preparation for fishing, mechanical aspects of fishing, and the capture and use of fish for food. A sub-dimension has been identified by Bryan (1974) involving the "experience of the catch." He identifies this aspect of the sport as "embodying the sporting, skill, and pursuit objectives of sport fishing." Factor 2 (Act of Fishing) deals with these aspects of a fishing experience and was important to certain groups of anglers.

Sixty-two percent of the anglers are spending over $100 per fishing trip. Much of this money is probably spent in the local area, but a breakdown was not available through the results of this questionnaire. The analysis of expenditures in this study provided little insight into the economic impact of anglers on the local community. Future studies on angler expenditures could provide useful information to local businesses and resource managers.

The age structure of the anglers had a significant effect on camping use and the reasons why people fish. The average age of the fishermen (49) and the percentage of anglers over 45 years (63%) would indicate the dominance of this group on the river. Seventy-percent of this age group stayed over 1 week and 28% stayed from 30 days to 90 days.

This age group had significantly different reasons for going fishing than did younger anglers. Preparation of tackle and the mechanical aspects of fishing were important to this group (excluding females). The sensory feelings toward nature were not significantly important to males, but were an important part of the females' experience. This is not consistent with results found by other researchers. Canadian salt water anglers indicated that nature-related aspects were highly important to their fishing experience (Bryan 1974).

Since most of the anglers in this group were spin or conventional gear fishermen, they are able to fish most of the water from the bank and have no need to wade. Many of these anglers did not have proper wading attire and expressed a fear of the river.

Anglers from 14 to 25 years and over 56 years considered fish as food an important aspect of their fishing experience. Findings for the younger age group are consistent with those described by Bryan (1974), but older anglers in Bryan's study indicated that the fish-oriented dimension of their experience was the least important. Many older Klamath River anglers were observed using the smoke-

house at Bluff Creek Campground. Anglers also had set up canning facilities in the campgrounds. Many people indicated that smoked and canned fish were an important food source throughout the rest of the year.

The escape factor has been identified by other researchers as important in a fishing experience. My conversations with anglers indicated that those who were not retired felt the need to get away from their normal routine and relax. This was important to their experience. On the other hand, many retired anglers felt no strong identification with the escape factor. Many felt that they had nothing to escape from and that responsibilities they once held were no longer important.

Females had different interests in a fishing experience than did males, indicating that the nature-related aspects of a fishing trip were the most important; that they showed little interest in other areas. Most of the women surveyed were accompanied by males and none was observed fishing alone.

Differences between spin fishermen and fly fishermen were apparent in regards to the wading factor and the food source factor. Spin fishermen on the Klamath are able to cover much of the fishable water from the bank. Fly fishermen usually are limited by the distance they can cast and must wade further to cover the fishable water. All fly fishermen observed on the river were actively wading. This familiarity with the river may be the reason fly fishermen rate wading so highly as part of their fishing experience. Fly fishermen were much younger as an age group and this also could account for the importance of this factor.

Responses concerning the factor "fish as food" and the regulation question on reducing the bag limits were different between spin and fly fishermen. Spin fishermen rated the food aspect of fishing as important to their experience and opposed lowering the bag limit. Fly fishermen rated fish as food low in importance and favored reduced bag limits. Philosophical differences between the two groups probably account for the disparity. The popularity of no-kill regulations and reduced bag limits has increased in recent years (Schwiebert 1979). Fly fishing publications and fly fishing clubs throughout the country have been active supporters of such regulations and recently supported legislation establishing no-kill waters in California (Fly Fisherman 1980). Information supporting reduced bag limits and no-kill regulations is made available to the public by the fly angling fraternity.

The intent of the reduced bag limit question was to determine how widespread the attitudes favoring reduced harvest were. Results in this study suggest that the majority of spin fishermen in this study did not support reduced bag limits.

The possibility does exist to establish certain stretches of water for limited or no-kill status. This may satisfy both groups of anglers, but would provide an enforcement problem for the California Department of Fish and Game. The same type of regulation could be provided for "flies only" water provided that enough support exists. This support was not evident in the spin fishing group, but was well supported by fly anglers.

Fisheries management encompasses three primary areas: the biology and life histories of fishes, the preservation and management of habitat, and management of anglers. Traditionally, fishery managers considered fish numbers in the

creel as the bottom line in management programs. This survey, as well as many similar studies, has shown that a variety of factors are involved in a successful fisheries program.

The fishing public is to a large degree responsible for the fiscal management of our resource agencies through tax revenues and license fees. Questionnaire surveys allow these anglers to voice their opinions on various management issues.

Issues that involve the management of a fishery, such as reducing the bag limit may be unpopular to certain groups of anglers, but may also be necessary to maintain a healthy fish population. By knowing public sentiment, managers can address these issues in public forums or by other means to help the public understand the reasons behind such regulations.

Questionnaires also provide a means to identify conflicts between various user groups. Spin fishermen and fly fisherman in this survey reflected different philosophies on a sport fishing experience. By recognizing differences between various user groups, fishery managers are better able to generate programs that meet the needs of each group.

LITERATURE CITED

Anon. California catch and release. Fly Fisherman 1980 Jan–Feb. P. 134.

Babbie, E. R. 1973. Survey research methods. Wadsworth Pub. Co., Belmont, Calif.

Bryan, R. C. 1974. The dimensions of a salt-water sport fishing trip. Southern Operations Branch Report. Fisheries and Marine Service of Canada. 35 pp.

Coots, M. 1952. Klamath River creel census, Copco to the Salmon River, Siskiyou County, 1949–1950. Report to Bur. Fish. Cons., Calif. Dept. Fish and Game. 64 pp.

Duttweiler, M. W. 1976. Use of questionnaire surveys in forming fishery management policy. Am. Fish. Soc., Trans. 105(2):232–239.

Hampton, E. L., and R. T. Lackey. 1976. Analysis of angler preferences and fisheries management objectives with implications for management. Proc. Ann. Conf. S.E. Assoc. Game and Fish Comm. 29:310–316.

Kesner, W. D. 1969. Characteristics of the fall-run steelhead trout (*Salmo gairdneri gairdneri*) of the Klamath River system with emphasis of the half-pounder. Humboldt State Univ. Thesis. 79 pp.

Moeller, G. H., and J. H. Engelken. 1972. What fishermen look for in a fishing experience. J. Wild. Management 36(4):1253–1257.

Phillips, B. S. 1966. Social research: strategy and tactics. MacMillan Pub., New York.

Schweibert, E. 1979. The Beaverkill River. Fly Fisherman. July–Aug pp. 52–58.

U.S. Fish and Wildlife Service 1960. Northwestern California, a preliminary survey of fish and wildlife. U.S. Fish and Wildlife Serv. Survey Report 104 pp.

Calif. Fish and Game 70(4): 210–224 1984

VARIABILITY IN AGE ESTIMATES IN *SEBASTES* AS A FUNCTION OF METHODOLOGY, DIFFERENT READERS, AND DIFFERENT LABORATORIES [1]

GEORGE W. BOEHLERT [2] and MARY M. YOKLAVICH
College of Oceanography and Marine Science Center
Oregon State University
Newport, Oregon 97365

Age was determined in the fast growing canary rockfish, *Sebastes pinniger,* and the slow growing splitnose rockfish, *S. diploproa,* by different laboratories, techniques, and readers. Variability between agencies depended upon method and species. For *S. pinniger* aged by both laboratories, whole otolith ages were similar, whereas the otolith section ages greatly exceeded those of whole otolith ages. Clear differences were noted for the slower growing *S. diploproa;* whole otolith ageing methods differed between the two laboratories, with much greater ages for larger specimens assigned by one laboratory. These older whole otolith ages showed similarities to the otolith section ages for this species, but still did not reveal the longevity noted with sections. We suggest two areas where improvement in precision of age determination is necessary. First, a consensus on ageing methodology (whole versus sectioned or broken and burned otoliths) is necessary to allow meaningful comparisons between readers. Secondly, mechanisms to allow comparisons between agencies or laboratories are necessary to provide ages which are, at the least, consistent, for use by fisheries managers.

INTRODUCTION

Using otoliths to define annuli and estimate age in fishes is difficult for several reasons. For fast growing species with clear otoliths, a consensus of different readers on age may be obtained, but for longer-lived species, age determination becomes more difficult and subjective (Williams and Bedford 1974, Maraldo and MacCrimmon 1978). The genus *Sebastes* is characterized by species with a great range of longevity, from maximum ages of about 4 to 5 years in *S. emphaeus* (Moulton 1975) to in excess of 80 years in several deeper living species (Beamish 1979*b*; Bennett, Boehlert, and Turekian 1982). In the longer-lived *S. marinus* and *S. mentella,* Sandeman (1961) noted only 9% agreement between readers; as expected, variability between readers increased with increasing age.

Different methods may also produce different results; ageing of *Sebastes* spp. has been conducted with scales (Phillips 1964), whole otoliths (Westrheim 1973, Boehlert 1980), and otolith sections (Beamish 1979*b*). Westrheim and Harling (1973) compared whole otolith versus scale methods for *S. alutus* and noted older ages from otoliths. Bias between readers in the same laboratory, using the same methods, is likely to be less than between agencies or laboratories (Kimura, Mandapat, and Oxford 1979). If, as on the Pacific coast, several agencies routinely age the same species, problems may arise for management in interpretation of the appropriate ages to use.

Whole otoliths are commonly used by management agencies in assessing age structure of a population. Several studies have indicated that a certain amount

[1] Accepted for publication December 1983.

[2] Mr. Boehlert's current address: National Marine Fisheries Service, NOAA, Southwest Fisheries Center Honolulu Laboratory, P.O. Box 3830, Honolulu, Hawaii 96812.

of bias is introduced with this method, especially where older individuals of the species are concerned. Growth of an otolith is a function of age as well as length of the fish. The otolith increases in length up to a given size of fish, after which it ceases to increase in length or width but continues to increase in thickness with age (Blacker 1974, Templeman and Squire 1956). This thickening occurs on the internal surface of the otolith, particularly in slow-growing, long-lived species. Relying solely on whole, surface ageing of the otolith's external surface will therefore neglect this cap of additional material. Certain investigators have found that using a section from an otolith reveals these internal banding patterns and suggest maximum ages which are double or even triple those estimated with whole otoliths (Sandeman 1961, Beamish 1979*a* and 1979*b*); that these older ages represent true ages has been demonstrated for *Sebastes diploproa* using natural radionuclides in otoliths by Bennett *et al.* (1982). Because management agencies are currently reassessing ageing techniques for rockfishes, a comparison of some of the alternative ageing methods and the variability within and between methods is desirable. In the present study we investigate deviations in estimated age of *S. diploproa* and *S. pinniger* as a function of different readers, different laboratories, and different methodologies.

MATERIALS AND METHODS

Sebastes diploproa and *S. pinniger* were sampled at depths from 32 to 205 fm by the chartered vessels F/V PAT SAN MARIE and F/V MARY LOU during the 1980 West Coast Groundfish Survey conducted by the Northwest and Alaska Fisheries Center, National Marine Fisheries Service. Gear, sampling techniques, and shipboard methods generally followed Gunderson and Sample (1980).

Sagittal otoliths were collected from fish captured in all hauls until sufficient numbers of specimens in specified length categories were obtained; very large and very small individuals thus represented a higher proportion in our sample than in the population. Specimens were numbered consecutively, as taken, within sexes. Vessel, leg, haul, sex, and fork length (to the nearest 0.1 cm) were recorded for each specimen. Additional information on each haul included latitude, longitude, and bottom depth. Both otoliths were removed, cleaned, and stored in individual, labelled vials containing 50% ethanol.

General information on otolith morphology and whole otolith ageing methodology in *Sebastes* is described in detail by Kimura *et al.* (1979). Whole otoliths for both species in our study were read with a dissecting microscope at 10x under reflected light. Otoliths were immersed in water on a black background. Generally, the best area to read was on the exterior surface of the whole otolith, from the focus to the dorsal edge. With fish older than approximately 12 yrs, a prominant annulus was followed to the posterio-dorsal or posterior region, where subsequent annuli were counted due to compression of annuli in the dorsal area. With older fish, particularly for *S. diploproa,* the whole otolith was rolled or tilted to enumerate annuli on the outer-most projections in the posterior region (Figure 1).

A single whole otolith age was determined for each specimen of *S. diploproa* by Oregon State University (OSU) reader A and *S. pinniger* by OSU reader B. Fish length remained unknown to all otolith readers, as recommended by Williams and Bedford (1974), among others, to minimize bias in otolith reading. A

second whole otolith age was assigned approximately ten weeks after the initial age assignments to determine within-reader differences. Further, for *S. diploproa,* whose otoliths are more difficult to read, one additional whole otolith age was determined by OSU reader C for an estimate of between-reader variability within an agency. After these ages were determined the entire sample of each species was sent to a different age reading laboratory (reader D) to establish inter-agency variability in whole otolith ages.

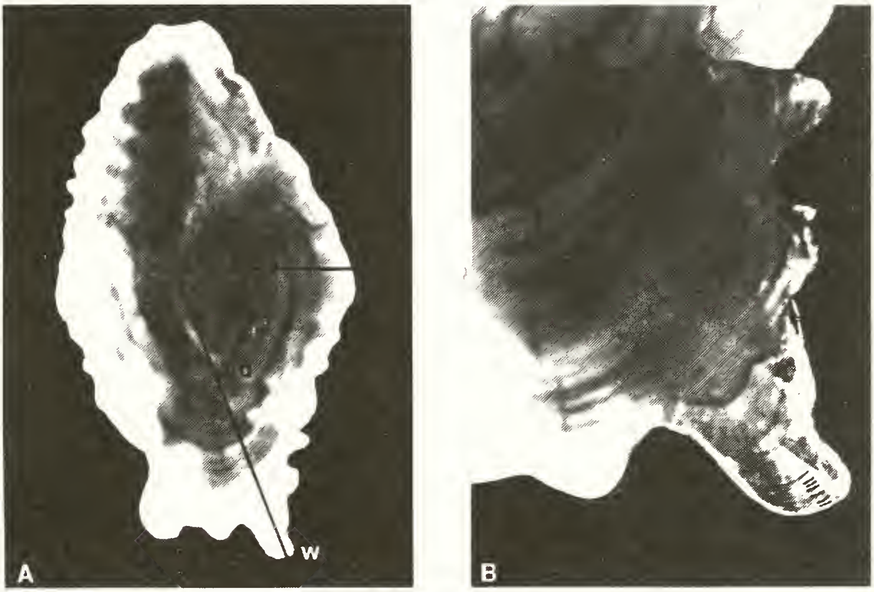

FIGURE 1. A. Exterior surface of the left otolith from a 308 mm FL male *Sebastes diploproa* (8X). The whole otolith age from OSU is 32 yrs. Readings were made from the focus to the dorsal edge (d — axis), continuing along a prominent annulus around to the posterio-dorsal (pd) axis. B. Enlarged portion of the posterior projections (w), showing additional annuli not apparent on the dorsal axis (32X).

The left otoliths of both species were subsequently prepared and sectioned as described by Boehlert (1984). Annuli of specimens younger than approximately 20 yrs were counted on a dissecting microscope using either transmitted or reflected light. The narrow annuli in otoliths from older fish were discerned using transmitted light on a compound microscope at approximately 10x. The ages were determined from the transmitted image on a video screen, for ease of enumeration on older fish. Annuli on the dorso-ventral axis, from the focus to the dorsal edge, are often split on otolith sections, making it difficult to identify the first several true annuli. For this reason, 25 whole left otoliths from *S. pinniger* and 50 from *S. diploproa* were selected, and distance was measured from the focus to accepted annuli (complete rings surrounding the focus) for approximately the first eight years. These measurements were used to identify the location of corresponding annuli on the same axis of the sectioned otolith and showed that our interpretation of annuli was similar between methods for young fish. By following these annuli to the internal, dorsal surface, only a single growth

zone was observed, as noted by Sandeman (1961); checks or false annuli found on the whole otolith either disappear or combine on this axis. Section ages were subsequently determined as described in Beamish (1979*b*). Section ages for both species were determined twice for each specimen by OSU reader A, approximately one month apart.

Since true age is not known with certainty for any otolith, initial whole ages determined by reader A for *S. diploproa* and by reader B for *S. pinniger* were considered as "standard age". Initial section ages by reader A in both species were considered "standard". To conduct multiple comparisons of variability, deviations from standard age were defined as shown in Table 1, where group 1 is the difference between independent ages determined by reader A for *S. diploproa* and by reader B for *S. pinniger*, group 2 (for *S. diploproa*) is the difference between standard whole age and that determined by reader C, group 3 compares standard whole otolith age with the age determined by reader D, group 4 is the difference between independent section ages determined by reader A, group 5 is the difference between standard section and standard whole otolith ages, and group 6 is the deviation of reader D whole age from standard section age. Deviations were normally distributed. A one-way analysis of variance (ANOVA) was used to compare these deviations for each species and sex. Multiple range testing was conducted using the Least Significant Difference method (p = 0.05) (Tables 2, 3, 4, 5).

TABLE 1. Identification of the Deviations of Standard Age to Define the Groups in Statistical Comparisons of Deviations.

Group	*Group definition*
1	whole otolith within-reader variation
2	between reader variation (*S. diploproa* only)
3	inter-agency variation
4	section within-reader variation
5	between-method variation
6	between-method-between-agency variation

TABLE 2: Results of One-Way Analysis of Variance and Multiple Range Test Comparing Deviations in Age of *Sebastes Diploproa* Females Determined by Different Readers and Methods. (Groups are defined in text and in Table 1.)

Analysis of Variance

Source	*D.F.*	*Sum of squares*	*Mean squares*	*F*	*P*
Between groups	5	6912.87	1382.57	41.78	<.001
Within groups	1718	56854.99	33.09		
Total	1723	63767.86			

Group	*N*	*Mean*	*Standard deviation*
1	290	0.217	2.018
2	290	−0.728	3.697
3	282	3.206	6.028
4	290	−0.024	2.156
5	290	2.007	6.711
6	282	4.993	9.831

Multiple range test (Least significant difference, P = .05)

Group 2 Group 4 Group 1 Group 5 Group 3 Group 6

TABLE 3: Results of One-Way Analysis of Variance and Multiple Range Test Comparing Deviations of Age in *Sebastes Diploproa* Males Determined by Different Readers and Methods. (Groups are defined in text and in Table 1.)

Analysis of Variance

Source	*D.F.*	*Sum of squares*	*Mean squares*	*F*	*P*
Between groups	5	7784.99	1557.00	36.97	<.001
Within groups	1466	61733.50	42.11		
Total	1471	69518.49			

Group	*N*	*Mean*	*Standard deviation*
1	246	−0.138	1.907
2	246	−0.537	2.669
3	244	2.598	4.972
4	246	0.126	2.445
5	246	3.427	8.595
6	244	5.865	11.746

Multiple range test (Least significant difference, P = .05)

Group 2 Group 1 Group 4 Group 3 Group 5 Group 6

TABLE 4: Results of One-Way Analysis of Variance and Multiple Range Test Comparing Deviations of Age in *Sebastes Pinniger* Females Determined by Different Readers and Methods. (Groups are defined in text and in Table 1.)

Analysis of Variance

Source	*D.F.*	*Sum of squares*	*Mean squares*	*F*	*P*
Between groups	4	1345.59	336.40	46.72	<.001
Within groups	600	4322.49	7.20		
Total	604	5668.08			

Group	*N*	*Mean*	*Standard deviation*
1	121	−0.050	0.717
3	121	1.413	1.838
4	121	0.017	3.152
5	121	2.455	3.209
6	121	3.868	3.449

Multiple range test (Least significant difference, P = .05)

Group 1 Group 4 Group 3 Group 5 Group 6

RESULTS

Sebastes diploproa

The sample of *S. diploproa* otoliths was comprised of 290 female and 246 male specimens. This sample was representative of the age, length, and latitudinal distribution of otoliths described in Boehlert (1984). Standard whole otolith ages ranged from <1 to 56 yrs for female and 1 to 40 yrs for males. Length frequencies and corresponding age distributions resulting from the various sources of age estimation were tabulated (Table 6). Females were generally more abundant in the large size categories. Mean ages-at-length, both for the females and males, showed distinct differences when comparing whole otolith age estimates from

different laboratories. Mean OSU ages were consistently lower than the other agency for the smaller, younger fish and were higher for those older and larger fishes (Table 6).

TABLE 5: Results of One-Way Analysis of Variance and Multiple Range Test Comparing Deviations of Age in *Sebastes Pinniger* Males Determined by Different Readers and Methods. (Groups are defined in text and in Table 1.)

Analysis of Variance

Source	*D.F.*	*Sum of squares*	*Mean squares*	*F*	*P*
Between groups	4	8779.49	2194.87	101.66	<.001
Within groups	850	18350.47	21.59		
Total	854	27129.96			

Group	*N*	*Mean*	*Standard deviation*
1	171	−0.029	0.747
3	171	−0.310	2.812
4	171	0.836	3.665
5	171	6.813	7.065
6	171	6.503	6.011

Group 3 Group 1	Group 1 Group 4	Group 6 Group 5

Reader variability in all comparisons generally increased with increasing fish length (and therefore age), and was greatest for older, larger females. The mean deviation in whole otolith ages between agencies as a function of whole standard age for both male and female *S. diploproa* (Figure 2) was much greater than either within or between reader differences within one laboratory. Up to age 10 for both sexes, OSU ages were more conservative than those of the other laboratory, resulting in negative deviations. After age 10, OSU whole ages were increasingly greater, up to a mean maximum deviation of about 30 yrs for the oldest females and 19 yrs for males. The negative deviations at younger ages could result from different interpretations of assumed annuli; OSU readers identified only complete rings as annuli, as compared with false annuli or checks, for the first several years of growth, although the first growth bands are admittedly difficult to interpret. The deviations at older ages are due to the inclusion of annuli on the posterio-dorsal projections of the otolith in the OSU age estimates (Figure 1).

Otolith section ages for *S. diploproa* were generally greater than whole otolith ages. Within-reader deviations for otolith section ages were similar to within and between-reader whole age deviations. Deviations were great when comparing section and whole ages. For both males and females, the mean deviations of whole from section ages at OSU were low for the first 30 yrs and began to diverge after this age (Figure 3). Maximum deviations were greater for males than for females (51 yrs and 29 yrs, respectively). Females grow faster than males and their otoliths are clearer. Annuli are easier to discern for older females on the surface of the whole otolith. The deviations of whole age from section age are therefore smaller in females. Moreover, from whole otolith estimates,

females appear to be older than males, whereas maximum ages estimated from sectioned otoliths reveal an opposite trend (66 yrs for females and 74 yrs for males).

Inter-agency differences between standard OSU section age and whole age from another laboratory as a function of standard section age (Figure 4) showed a pattern similar to that for section-whole deviations within an agency, with a few important exceptions. Mean deviations at ages greater than 10 yrs are greater in the inter-agency comparison and are negative at ages less than 10 yrs. This further emphasizes the difference in ageing criteria used between laboratories. In addition, the deviations diverge from zero at a much lower age; that is, divergence is at 10 yrs for inter-agency and 30 yrs for within-agency comparisons, reflecting the older whole otolith ages determined by OSU.

Sebastes pinniger

This study utilized 121 female and 171 male *S. pinniger* otoliths. As with *S. diploproa*, females were more abundant in the largest size categories (Table 7), apparently due to their faster growth rate (Boehlert 1980, Boehlert and Kappenman 1980). Standard whole ages ranged from 2 to 22 yrs for females and 2 to 25 yrs for males. Mean ages-at-length were generally higher for OSU estimates when compared with the other agency (Table 7).

Otoliths of *S. pinniger* are generally clearer, easier to read, and this species does not reach the ages attained by *S. diploproa*. As expected, mean interagency differences in whole otolith ages were minimal when compared with those of the more difficult to read *S. diploproa* otoliths. Moreover, although section ages were generally greater than whole ages, the magnitude of this deviation was not as great as that observed for *S. diploproa*. This reflects the greater clarity and ease in surface reading of *S. pinniger* otoliths (Figure 5).

Mean within-reader differences were similar in both whole and section age comparisons. Inter-agency differences between OSU standard section age and whole age from the laboratory were similar to within-agency differences of the same comparison; this results from closer estimates of whole ages between agencies. Considering this comparison (between methods), deviations were high but less than those for *S. diploproa*. Maximum between-method deviations, from OSU as well as the other laboratory, were higher for the slower growing, longer-lived males, as observed for *S. diploproa*.

One-way analyses of variance demonstrate significant differences between the sources of deviations in age for both males and females of both species of *Sebastes* (Tables 2,3,4,5). Multiple range testing suggests that mean within-agency sources of deviation for *S. diploproa* (including within-reader for both whole and section ages and between-reader) are similar and significantly less than inter-agency deviations. Consequently, precision in age determination can be high among readers within one laboratory, but can decrease greatly when comparing ages between laboratories. These results also suggest that precision is highly dependent upon the method used in age determination, with comparisons of ages derived through different methods by different laboratories resulting in the greatest deviations.

TABLE 6. Mean Ages-at-Length for Different Readers and Methods of Age Determination in *Sebastes diploproa*.

A. Female (N=290)

Length (cm)	*N*	Whole otolith age *A1*	Whole otolith age *A2*	Whole otolith age *C*	Whole otolith age *D*	Otolith section age *A1*	Otolith section age *A2*
13	1	2.0	2.0	3.0	4.0	2.0	2.0
14	2	2.0	2.0	2.5	4.5	2.5	2.5
15	4	3.5	3.5	3.5	4.5	3.3	3.3
16	5	3.8	3.2	4.8	5.0	3.4	3.6
17	5	4.4	4.0	5.4	5.2	4.2	4.4
18	7	5.1	4.3	5.7	5.4	5.3	5.1
19	8	5.5	5.4	6.4	5.9	5.6	5.5
20	11	6.2	6.1	7.1	6.0	6.0	6.1
21	15	6.3	6.3	6.9	6.9	6.8	6.3
22	12	6.9	6.6	7.9	7.2	7.6	7.5
23	24	7.4	7.3	8.1	7.3	7.5	7.3
24	19	7.4	6.9	7.7	7.3	7.5	7.7
25	13	8.3	8.2	9.5	8.1	10.8	10.5
26	25	9.2	9.4	10.3	9.0	9.6	9.1
27	23	9.4	10.1	10.1	9.2	9.3	9.3
28	10	12.3	11.6	12.0	11.1	11.4	11.3
29	16	16.6	16.3	16.9	12.6	17.3	17.6
30	17	23.1	23.4	22.1	15.6	22.9	23.2
31	15	23.5	25.1	25.3	17.0	25.7	26.1
32	8	28.1	30.0	32.0	21.5	30.4	31.3
33	11	30.1	30.2	33.2	20.1	39.6	40.2
34	9	32.9	36.8	36.7	22.6	48.9	48.3
35	7	39.1	39.0	34.9	23.5	42.9	40.7
36	15	38.3	39.1	38.7	22.2	48.9	49.6
37	7	38.1	37.0	34.9	24.7	40.1	42.0
38	1	36.0	38.0	48.0	18.0	62.0	63.0

B. Male (N=246)

Length (cm)	*N*	Whole otolith age *A1*	Whole otolith age *A2*	Whole otolith age *C*	Whole otolith age *D*	Otolith section age *A1*	Otolith section age *A2*
9	1	1.0	1.0	1.0	3.0	1.0	1.0
11	1	3.0	3.0	3.0	4.0	4.0	4.0
12	1	1.0	1.0	1.0	3.0	1.0	1.0
13	1	1.0	1.0	1.0	3.0	1.0	1.0
14	2	3.5	3.5	4.0	5.0	3.5	1.5
15	5	4.0	2.8	4.2	4.8	4.2	5.6
16	3	4.0	4.0	3.7	4.7	4.0	4.0
17	3	5.0	4.7	5.7	5.3	6.0	6.0
18	8	5.0	4.9	5.6	6.4	5.9	5.5
19	7	5.3	5.0	5.9	6.0	5.4	5.7
20	11	5.5	5.4	6.1	6.1	5.7	5.8
21	16	7.0	6.7	7.0	6.9	6.9	6.9
22	23	7.2	7.1	7.6	7.2	7.3	7.6
23	22	7.7	7.6	8.2	7.4	7.9	8.0
24	16	8.9	8.4	9.1	8.2	9.1	8.9
25	13	8.4	8.4	9.4	9.4	8.7	8.9
26	24	9.6	9.1	9.8	10.0	9.6	9.6
27	13	14.2	13.6	14.2	10.8	14.5	14.9
28	13	19.5	18.4	19.5	13.9	23.4	20.5
29	17	26.7	27.4	27.4	19.1	32.6	34.1
30	15	26.1	26.5	28.9	18.3	33.1	31.3
31	12	29.0	28.9	28.1	16.9	43.3	43.1
32	14	30.2	31.4	31.2	20.1	49.1	48.2
33	3	25.7	25.7	29.7	14.0	47.3	46.7
34	1	30.0	31.0	35.0	19.0	54.0	57.0
36	1	32.0	30.0	33.0	22.0	68.0	69.0

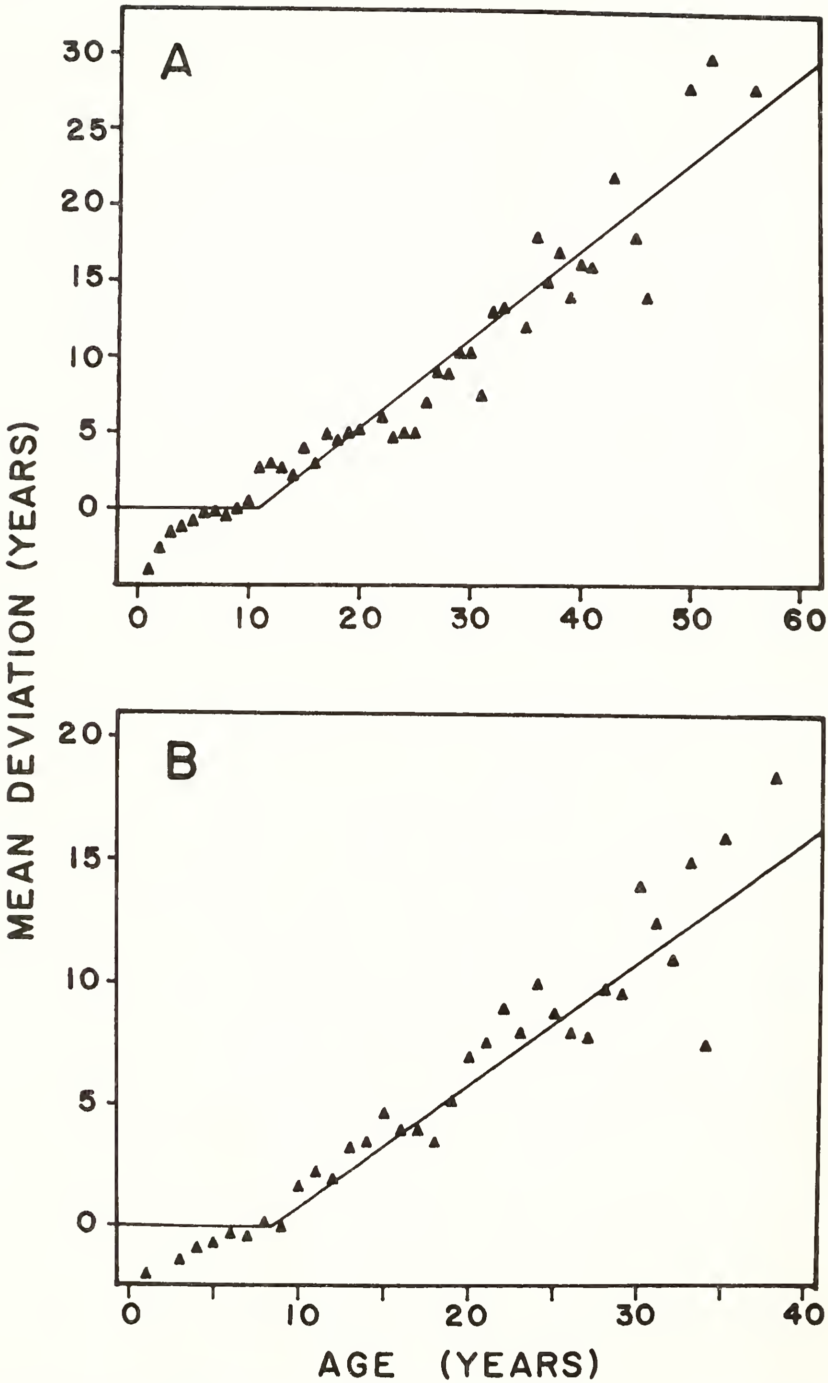

FIGURE 2. Mean deviations in whole otolith ages between agencies for splitnose rockfish, *Sebastes diploproa*. A. Females (N = 290). B. Males (N = 246).

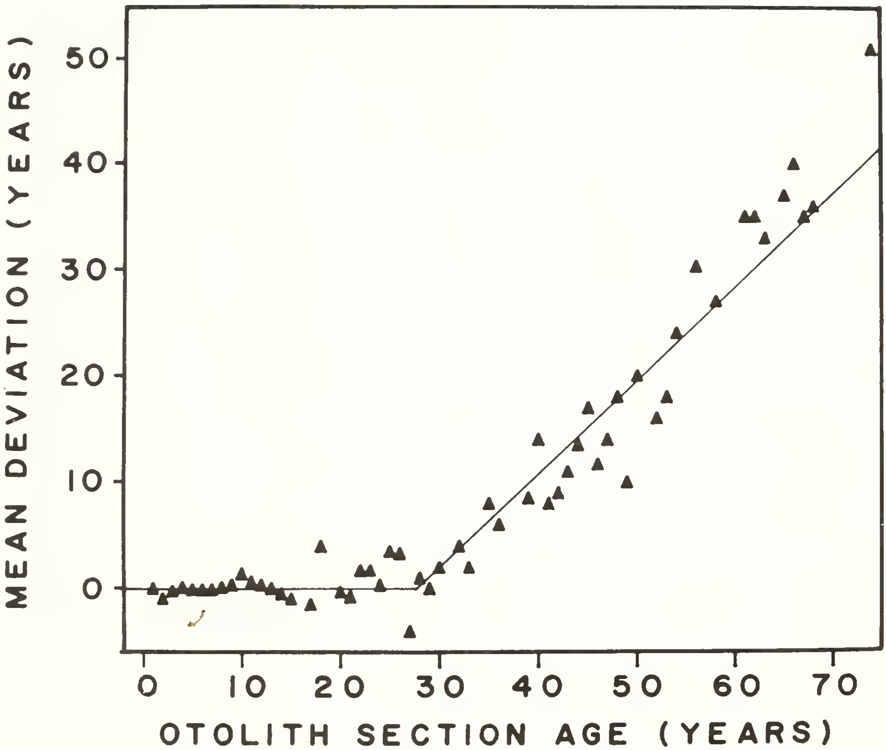

FIGURE 3. Mean deviation of OSU whole otolith age from otolith section age for male *Sebastes diploproa* (N = 246).

For *S. pinniger,* multiple range testing demonstrated similar trends, with deviations in age being greatest when comparing methods both between and within agencies. Inter-agency deviations are relatively low, however, when comparing whole ages from these clear, easy-to-read otoliths.

DISCUSSION

This study does not conclude that assigned ages are accurate, since age validation is beyond the scope of this study. It does suggest that age determination using whole otoliths will not adequately represent the age of most *S. diploproa* beyond 30 yrs and *S. pinniger* beyond age 10 yrs. Section ages seem to more accurately define the age composition of a population, particularly in the case of longer-lived species with difficult-to-read otoliths (Bennett *et al.* 1982). It would therefore be beneficial to examine otoliths from other species of rockfish to determine at what age, if any, it becomes necessary to section the otolith to estimate the true age of the fish. A method which provides results similar to sectioning is the break and burn technique, as described by Chilton and Beamish (1982). This technique, which also involves examination of an otolith cross section, may be more amenable to production-type age determination than the sectioning methods used in the present study. In the genus *Sebastes,* however, it is apparent that these greater ages exist in a wide variety of species (Shaw and Archibald 1981).

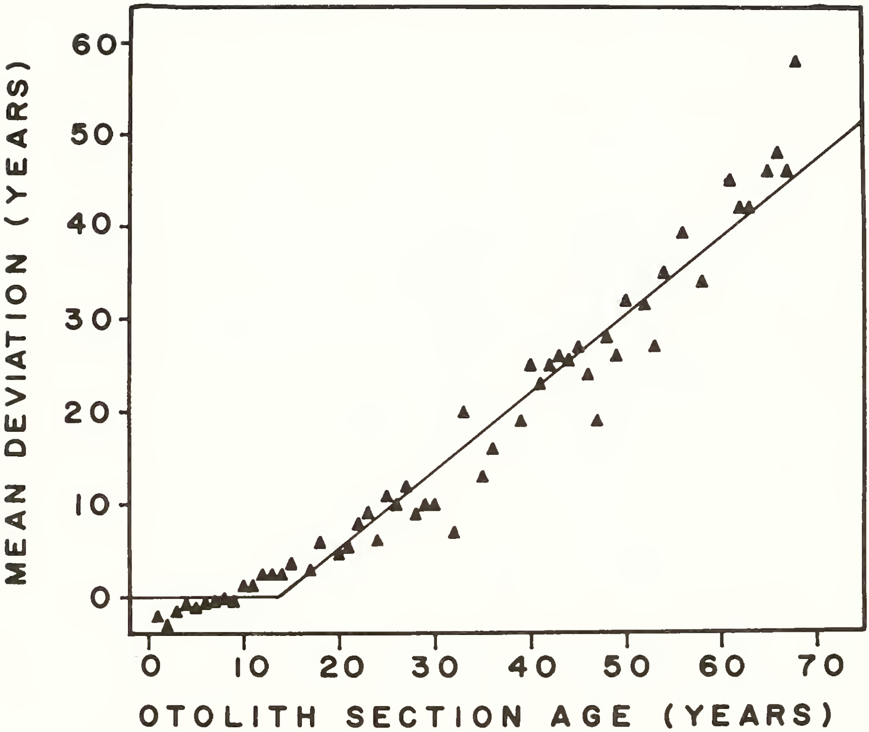

FIGURE 4. Differences between otolith section ages and whole otolith ages from another agency for male *Sebastes diploproa* (N = 246).

It is clear from our results that an important part of the populations of both species is significantly underaged using the whole otolith technique, particularly by the other laboratory (Figures 3,4,5). An important point to note from these data is the fact that the deviations for males are generally greater than those for females. Female *Sebastes* grow faster than males for most species (Boehlert and Kappenman 1980, Westrheim and Harling 1975) and are therefore characterized by otoliths which have broader, clearer annuli on whole otoliths to a greater age. Thus, the age at which the otolith growth occurs only as "caps" on the internal surface will be greater for females. Using whole otoliths for age determination, the females will appear to be older than the males whereas the opposite is actually true based upon section age (Tables 6 and 7). The systematic bias which is introduced by using whole otolith ages is therefore compounded by differences in the error of longevity estimates for males and females.

These older fish represent an important part of the population which should not be ignored. Hirschhorn (1974) argued that excluding older, difficult-to-age individuals from growth analysis for the population can have detrimental effects upon estimates of von Bertalanffy parameters. For production modelling or stock analysis purposes, unbiased errors in age determination, particularly for older segments of the population, will have little effect, whereas systematic bias in

TABLE 7. Mean Ages-at-Length For Different Readers and Methods of Age Determination in *Sebastes pinniger*.

A. Female (N=121)

Length (cm)	N	Whole otolith age B1	Whole otolith age B2	Whole otolith age D	Otolith section age A1	Otolith section age A2
15	1	2.0	2.0	2.0	2.0	3.0
31	1	5.0	5.0	4.0	7.0	7.0
32	2	5.5	5.0	3.5	7.0	7.0
33	1	4.0	4.0	3.0	3.0	4.0
36	1	9.0	9.0	8.0	13.0	12.0
37	1	7.0	7.0	6.0	8.0	8.0
38	3	7.0	7.3	6.3	8.3	10.7
39	1	6.0	6.0	5.0	6.0	6.0
41	3	8.0	8.0	7.7	10.3	10.3
42	2	9.5	9.5	8.0	10.5	10.5
43	2	8.0	8.0	7.5	11.0	11.0
44	1	9.0	9.0	8.0	10.0	9.0
45	2	11.0	11.0	10.0	12.0	13.5
46	5	11.0	11.4	9.0	11.4	11.8
47	4	11.0	11.0	8.0	12.5	10.5
48	7	11.9	12.0	11:1	12.7	13.0
49	8	11.8	12.0	10.5	12.3	13.4
50	5	11.2	11.4	10.8	12.6	16.4
51	10	12.8	12.7	11.2	15.6	14.9
52	9	13.1	13.1	10.7	14.9	13.9
53	18	13.6	13.6	12.2	16.8	16.6
54	6	13.5	13.8	12.8	16.0	15.8
55	8	15.4	15.3	14.1	18.5	17.6
56	9	15.7	15.2	13.8	19.9	19.6
57	5	14.6	14.8	12.6	19.4	19.6
58	2	16.0	16.5	15.5	17.0	15.5
59	1	16.0	16.0	16.0	28.0	27.0
60	1	17.0	16.0	11.0	15.0	26.0
61	2	18.5	20.0	17.0	30.5	26.5

B. Male (N=171)

Length (cm)	N	Whole otolith age B1	Whole otolith age B2	Whole otolith age D	Otolith section age A1	Otolith section age A2
17	1	2.0	2.0	2.0	2.0	3.0
20	1	3.0	3.0	3.0	3.0	3.0
22	1	3.0	3.0	3.0	3.0	4.0
23	1	3.0	3.0	3.0	4.0	5.0
28	1	5.0	5.0	5.0	6.0	6.0
34	2	7.0	7.0	6.5	8.5	8.0
37	2	6.0	6.0	4.0	7.0	8.0
38	1	7.0	7.0	5.0	9.0	8.0
39	1	8.0	8.0	8.0	13.0	10.0
40	5	8.0	8.0	7.8	9.2	9.6
41	2	7.5	7.5	7.0	8.5	12.5
42	4	8.3	8.3	6.5	7.8	9.3
43	4	10.3	10.5	8.0	12.5	14.8
44	4	9.5	9.5	9.5	11.3	13.5
45	4	12.5	12.5	9.8	15.3	18.5
46	7	11.6	11.9	10.9	15.1	16.7
47	16	11.8	11.8	11.4	15.1	15.4
48	9	13.0	12.9	13.2	15.7	16.4
49	13	12.8	13.5	13.8	18.0	18.3
50	25	13.3	13.4	13.7	19.2	20.6
51	14	15.1	15.3	16.2	26.4	27.7
52	18	15.5	15.4	15.8	25.3	25.9
53	17	17.3	17.0	19.5	29.6	29.8
54	7	15.9	16.0	17.9	28.9	29.4
55	4	18.8	18.8	19.5	33.3	30.8
56	2	18.5	18.0	21.5	43.0	50.5
57	4	18.8	18.8	17.8	29.8	29.0
58	1	16.0	15.0	15.0	32.0	25.0

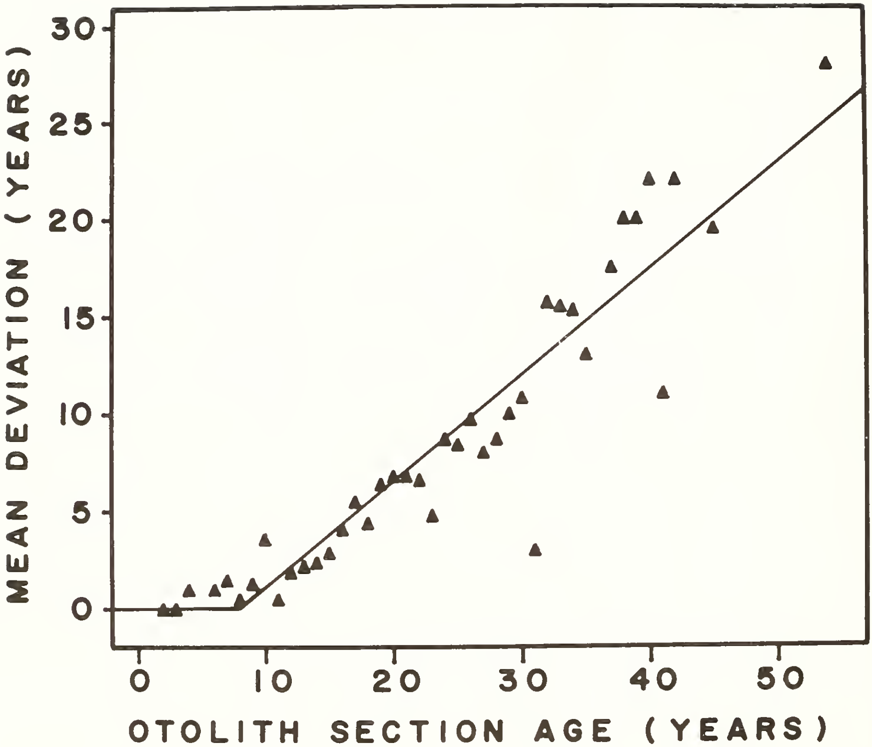

FIGURE 5. Differences between section age and whole otolith age determined by another agency for male *Sebastes pinniger* (N = 171).

ageing may give rise to serious errors (LeCren 1974). Thus, the systematic errors introduced by using ages determined from whole otoliths will negatively affect production models. Calculations of both natural and fishing mortality will clearly be in error, and use of such age data in cohort analysis or virtual population analysis will result in inaccurate cohort strength estimates.

It is difficult to define the causes of the systematic error between agencies. Some error may arise from method alone. Use of different magnifications, for example, may result in different visibility of annuli. Reading otoliths with transmitted versus reflected light, in aqueous media versus dry, or other minor changes in method may result in such systematic differences. Methodological problems will be easiest to solve. Differences in interpretation are more difficult to address. Ages determined within agencies may show high precision and repeatability, but differ significantly from ages at another agency. This suggests that training and frequent cross-checking can solve the problems between agencies.

This study represents an effort to consider the errors inherent in ageing rockfish based upon reader variability, method variability, and agency variability. We concur with Kimura *et al.* (1979), that variability among agencies is greater than

that between readers in the same laboratory. We suggest that significant effort be placed upon minimizing variability between agencies. A necessary first step to this goal will be standardization of methods and equipment for ageing each species. Within each species, common interpretation of criteria for defining annuli must be developed. Achieving this goal will initially take a great deal of uniform training and interagency calibration. Continued communication among otolith readers of different agencies, while expensive in time and travel, will ultimately result in more effective fisheries management.

ACKNOWLEDGMENTS

We thank D. Gadomski, R. Taylor, and R. McClure for technical assistance on this project, and T. Dark and M. Wilkins (NWAFC) and other participants in the 1980 West Coast Survey. Finally, particular thanks go to Captains B. and T. Hansen and the crews of the F/V PAT SAN MARIE and F/V MARY LOU for their diligence and effort in this survey. This research was supported by Cooperative Agreement Number 80-ABH-00049 and Contract Number 81-ABC-00192-PR6 from the Resource Assessment and Conservation Engineering Division, National Marine Fisheries Service, Seattle, Washington. We thank M. Hayes for his continued interest in ageing research.

LITERATURE CITED

Beamish, R. J. 1979*a*. Differences in the age of Pacific hake, (*Merluccius productus*) using whole otoliths and sections of otoliths. Can. Fish. Res. Bd., J. 26: 141–151.

________. 1979*b*. New information on the longevity of the Pacific ocean perch (*Sebastes alutus*). Can. Fish. Res. Bd., J. 36: 1395–1400.

Bennett, J. T., G. W. Boehlert, and K. K. Turekian. 1982. Confirmation of longevity in *Sebastes diploproa* (Pisces: Scorpaenidae) from ^{210} Pb/^{226}Ra measurements in otoliths. Mar. Biol., 71: 209–215.

Blacker, R. W. 1974. Recent advances in otolith studies. Pages 67–70 *in* F. R. Harden Jones, ed. Sea Fisheries Research. Elek Science, London.

Boehlert, G. W. 1980. Size composition, age composition, and growth of canary rockfish, *Sebastes pinniger* and splitnose rockfish, *S. diploproa,* from the 1977 Rockfish Survey. Mar. Fish. Rev., 42: 55–60.

Boehlert, G. W. 1984. Using objective criteria and multiple regression models for age determination in fishes. Fish. Bull. (U.S.) 82 (4): in press.

Boehlert, G. W., and R. F. Kappenman. 1980. Variation of growth with latitude in two species of rockfish (*Sebastes diploproa* and *S. pinniger*) from the northeast Pacific Ocean. Mar. Ecol. Prog. Ser., 3: 1–10.

Chilton, D. E., and R. J. Beamish. 1982. Age determination methods for fishes studied by the groundfish program at the Pacific Biological Station. Can. Spec. Publ. Fish. Aquatic Sci., 60: 102 p.

Gunderson, D. R., and T. Sample. 1980. Distribution and abundance of rockfish off Washington, Oregon, and California during 1977. Mar. Fish. Rev., 42: 2–16.

Hirschhorn, G. 1974. The effects of different age ranges on estimated Bertalanffy growth parameters in three fishes and one mollusk of the northeastern Pacific Ocean. Pages 192–199 *in* Bagenal, T., ed. The Ageing of Fish. Unwin Brothers, Ltd., London.

Kimura, D. K., R. R. Mandapat, and S. L. Oxford. 1979. Method, validity, and variability in the age determination of yellowtail rockfish (*Sebastes flavidus*), using otoliths. Can. Fish. Res. Bd., J. 36: 377–383.

LeCren, E. D. 1974. The effects of errors in ageing in production studies. Pages 221–224 *in* Bagenal, T., ed. The Ageing of Fish. Unwin Brothers, Ltd., London.

Maraldo, D. C., and H. R. MacCrimmon. 1978. Comparison of ageing methods and growth rates for largemouth bass, *Micropterus salmoides* Lacepede from northern latitudes. Env. Biol. Fish., 4: 263–271.

Moulton, L. 1975. Life history observations of the Puget Sound rockfish, *Sebastes emphaeus* (Starks, 1911). Can. Fish. Res. Bd., J. 32: 1439–1442.

Phillips, J. B. 1964. Life history studies on ten species of rockfish (genus *Sebastodes*). Calif. Dept. Fish Game, Fish. Bull. (126) 70 p.

Sandeman, E. J. 1961. A contribution to the problem of age determination and growth rate in *Sebastes*. Rapp. P.V. Reun. Cons. Perm. Int. Explor. Mer, 150: 276–284.

Shaw, W., and C. P. Archibald. 1981. Length and age data of rockfishes collected from B.C. coastal waters during 1977, 1978, and 1979. Can. Data Rept. Fish. Aquat. Sci., No. 289. 119 p.

Templeman, W., and H. J. Squires. 1956. Relation of otolith lengths and weights in the haddock *Melanogrammus aeglefinis* (L.) to the rate of growth of the fish. Can. Fish. Res. Bd., J. 13: 467–487.

Westrheim, S. J. 1973. Age determination and growth of Pacific ocean perch (*Sebastes alutus*) in the northeast Pacific Ocean. Can. Fish. Res. Bd. J., 30: 235–247.

Westrheim, S. J., and W. R. Harling. 1973. Report on the 1972 comparison of Pacific ocean perch otolith and scale interpretations. Fish. Res. Bd. Can., Manuscript Rept., Ser. No. 1259. 24 p.

———. 1975. Age-length relationships for 26 scorpaenids in the Northeast Pacific Ocean. Fish. Mar. Serv. (Can.) Res. Dev. Dir., Tech. Rep. 565. 12 p.

Williams, R., and B. C. Bedford. 1974. The use of otoliths for age determination. Pages 114–123 *in* Bagenal, T., ed. The Ageing of Fish. Unwin Brothers, Ltd., London.

Calif. Fish and Game 70(4): 225–233 1984

ESTIMATION OF SEA OTTER, *ENHYDRA LUTRIS*, POPULATION, WITH CONFIDENCE BOUNDS, FROM AIR AND GROUND COUNTS [1]

JOHN J. GEIBEL
California Department of Fish and Game
Planning Branch
Menlo Park, California 94025
And
DANIEL J. MILLER
California Department of Fish and Game
Marine Resources Branch
Monterey, California 93940

Various methods have been used since 1938 to estimate the sea otter population off of central California. The method presented here is similar to a single mark and recovery experiment in which airplane observed otters are "marked" and shore observed otters consist of recoveries of "marked" otters (those seen from the plane) and "unmarked" otters (those not seen from the plane). From these data, total population can be estimated and variance calculated. Biases inherent in this model will result in conservative estimates of the population.

INTRODUCTION

The sea otter in central California has returned from a population of around 50–100 animals in the early 1900's to presently estimated levels of about 1800 to 2000 (Miller 1980). Before the initiation of the California Department of Fish and Game (CDFG) sea otter research project in 1968, counts of portions of the range and total censuses were made from shore and by airplane (Miller 1958, Boolootian 1961, Carlisle 1965). The first total census was made in 1938 by Donald McLean (CDFG), from shore.

From 1968 to 1970, 14 aerial censuses were made by Melvin Odemar and Kenneth Wilson of CDFG. On three of these flights aerial counts were compared with shore and boat counts in certain sections of the flight coverage (Wilson 1968*a*, 1968*b;* Odemar 1969). These initial aerial-ground comparisons revealed that 0 to over 40% of the animals could be missed by the aerial observers. There was a higher degree of undercounting from the air on bright sunny and windy days and when the otters were rafting in dense bull kelp canopies *(Nereocyctis)*. These ground-aerial comparisons were either not conducted on the same day or were tallies of animals scattered over extensive areas and were not simultaneous counts of isolated single groups of animals. Therefore, part of the inconsistency in counts was probably due to movement of animals in and out of the aerial and ground comparison areas between the time comparisons were made by observers. Aerial counts were completed in a few minutes and the ground count sometimes took several hours. On other surveys observations were made a day apart.

Wild and Ames (1974) converted aerial counts to population estimates by using subjective adjustments for their tallies based on flight conditions. In 1973,

[1] Accepted for publication October 1982.

Daniel Miller organized an intensive ground-truth operation in conjunction with a routine aerial census (Wild 1973). Thirty-four ground-truth stations were utilized to record single groups of otters as the plane flew over. These direct comparisons revealed that in these thirty-four stations the aerial observers tallied 62% of the animals recorded by the ground counters. In 1974, two more censuses were made and the aerial counts were 71% and 60% of the animals recorded in the ground-truth stations. Total population estimates were made using a direct ratio method based around size grouping of otters (California Department of Fish and Game 1976). A group was loosely defined as otters in close proximity to one another. The ratios (air/ground) were compiled by group size and a least squares regression was fit to these data. The aerial counts for the entire census were tallied by group size and adjustments were made based upon the regression. A model similar to this method was developed by Samuel and Pollock (1981).

It seemed reasonable to take group size into account because individuals or small groups of otters would be easier for air observers to miss than would larger rafts of animals. This method assumed that ground observers counted all otters in their area. It was known that ground observers missed animals, but since no empirical methods had been developed to estimate this value, it was assumed to be zero. An exception to this assumption occurred in a few areas where air observers saw animals which had been missed from the ground. These animals were added to the ground count. The direct ratio model gave the first estimate of the California sea otter population with confidence limits.

There were two known sources of error in this model. The first was the assumption that ground observers counted all animals. The second was the ranking of otters by group size. Otters seldom form well defined groups and it was often an arbitrary decision as to whether rafting otters in a kelp bed formed one large group or three or four smaller but contiguous groups. Likewise, on several occasions the airplane on the first pass frightened a large group of rafting otters scattering animals so that on subsequent passes, smaller groups and separate individuals were seen by observers.

The problem of determining group size is subjective and does not lend itself to a reliable analytical solution. However the number of animals missed by ground observers can be estimated from the few cases when aerial observers saw animals that ground observers missed. Using the 1976 sea otter census, we developed a method of estimating the percentage of otters missed by ground observers. With simple substitution, we found that this method could be used to estimate the percentages missed by aerial observers with the advantage of eliminating the need for ground observers to count all animals in their areas. In addition we found it unnecessary to rank otters by group size.

This model is close to the ratio method and in fact when ground observers miss no animals, the two methods would give identical results. However, from the 1975 and 1976 census, it appears that ground observers miss 10% to 17% of the animals in their areas (Table 1).

In our analysis of the 1975 census, when air observers counted an animal that was missed from the ground, that animal was added to the ground count in that area. However this cannot account for animals missed from both the plane and the ground. If the plane misses about 30% to 40% of the animals, then the plane

should also miss about one out of three animals that the ground observers miss. This would result in the total ground count being low by 3% to 6% (Table 1). Resultant ratio estimates (air/ground) would then be high leading to small but consistent under-estimates of the total population size. The ratio could be adjusted to take this into account, but then we would be working with combined variances: the variance around the air count and the variance around the ground count.

The method developed for analysis of the 1976 census avoids the problem of estimating animals missed by ground observers and combining the variances to calculate confidence intervals around these estimates. In addition, biases that would result in inaccurate population estimates are the same for either method. Any animals that are not visible to both air and ground observers will not enter into the result. In essence, we could divide the total population into two groups: those that are visible and those that are not visible. The census would only be able to estimate the visible group no matter what method is developed or used for analysis. Hopefully most otters are visible to ground or air observers.

TABLE 1. Percentage of Observed and Total Estimated Otters Counted by Ground and Air Observers in Ground Truth Stations

		Observed			*Total estimated*			
Date	*Ground*	*Number*	*Percent by Ground*	*Percent by Air*	*Number*	*Percent by Ground*	*Percent by Air*	*Percent by Air and by Ground*
14	277	297	93.3	71.4	306	90.5	69.3	97.0
15	334	363	92.0	71.9	376	88.8	69.5	96.5
16	369	414	89.1	65.9	442	83.5	61.5	93.7
14–16	980	1074	91.2	69.7	1124	86.9	66.4	95.2

METHODS AND MATERIALS

This method of analyzing sea otter census data was made possible by detailed maps of the coastline in which up-to-date outlines of kelp beds were drawn (Miller 1976). Using these maps sea otters could be accurately depicted in kelp beds, around rocks, or in coves to allow comparison between air and ground counts.

If we assume that the probability of sighting an otter has a binomial distribution, then the following model can be used.

Let N be the total number of animals present in the flight area, and n_1 be the total number of animals counted from the air, then the probability of seeing an animal from the air is $p_1 = n_1/N$. If we know p_1 and n_1, then our population estimate is $\hat{N} = n_1/p_1$.

The flight area is divided into contiguous subarea, k of which are selected at random for ground counts.

N_i = number of otters in ith subarea ($i = 1, 2, \ldots, k$),

n_{1i} and n_{2i} are the number of animals counted from the air and the ground respectively in ith subarea

p_{1i} and p_{2i} are the probability of including an animal in the count from the air and ground respectively in ith subarea, and

m_1 is the animals seen in common by both air and ground observers in the ith subarea. The following relationships hold;

$$p_{1i}N_i = n_i,\ p_{2i}N_i = n_2, \text{ and } p_{1i}p_{2i}N_i = m_i$$

Rearranging terms and substituting we get

$$p_{2i} = n_2/N_i,\ p_{1i}\left(\frac{n_{2i}}{N_i}\right)N_i = m_i$$

or $P_{1i} = m_i/n_{2i}$.

Summing over all ground count areas, $i = 1, 2, \ldots, k$, we get

$$\hat{p}_1 = \frac{\sum_{i=1}^{k} m_i}{\sum_{i=1}^{k} n_{2i}}$$

the variance around $\hat{p}_1$ is

$$V[\hat{p}_i] = \hat{p}_1(1-\hat{p}_1)/(n_1-1) \qquad (1)$$

However, as sample size approaches population size, variance should be calculated from

$$V[N] = \frac{(n_1+1)(n_2\ \ 1)(n_1-m)(n_2-m)}{(m+1)^2(m+2)} \qquad (2)\ \text{(Seber, 1973, p. 60)}$$

where variance is given in numbers and is unbiased when

$$n_1 + n_2 > N$$

Sites for shore count stations were chosen in advance and marked with surveying tape for ease of location by shore observers driving along the highway. When an inordinate amount of time would be required to get to and from an observation point, when private property had to be crossed and permission to trespass could not be obtained, or when shoreline profiles were so low as to allow viewing only a short distance offshore, sections were not included as potential ground truth stations. However, the present sea otter range includes some of the most precipitous coastline of California, and Highway 1 runs directly along the ocean over most of the sea otter range. In addition, property owners have been most cooperative in allowing access to sea otter counters. Consequently only about 20% of the sea otter range was excluded from random selection for shore counting.

Each ground observer was assigned two to three stations, depending on time involved in getting from one site to the next, and given copies of topographical maps (20mm = 160m) on to which details of kelp beds, rocks, or other prominent features were drawn. The air observers had duplicate maps.

Ground observers occupied stations at least 20 minutes prior to the estimated arrival of the plane to locate any otters in their area and to draw onto maps the

visual limits to which accurate counts could be made. Sea otters were noted and followed until the plane arrived. At this time, otters, along with a concise description as to whether the animal was rafting, swimming or feeding, were marked on maps. Other animals such as sea lions, seals, etc. or unusual objects were also marked on maps. This proved useful in relating otters on air and ground maps.

At the end of each day, shore counters and air counters assembled and compared maps. Inconsistencies were discussed and resolved while memories were still fresh. This was especially important when otters were moving while air counts were being made. Such animals could move several hundred yards in the few minutes it would take air observers to count the area. Consequently, apparent discrepancies between air and ground maps could often be quickly resolved by comparing behavior, direction of movement, number of animals, etc.

Otters were tallied by area as to those seen by air, those seen by ground, and those seen in common. Mothers with clinging pups or dependent animals carried on the ventral surface of the mother, were tallied as a single free swimming animal because such pairs were difficult for aerial observers to distinguish as two individuals. Clinging pups were analyzed separately (Table 2).

TABLE 2. Number of Clinging Pups Counted from Shore, n_2, and Number Seen by Air and Ground, m, for 14, 15, and 16 June 1976.

Area	*Day*					
	14 June 76		*15 June 76*		*16 June 76*	
i	n_{2i}	m_i	n_{2i}	m_i	n_{2i}	m_i
1	1	0	1	0	1	0
2	1	1	1	0	2	0
3	2	0	1	0	1	0
4	1	0	1	0	1	0
5	2	0	1	0	4	0
6	1	1	1	0	1	0
7	1	0	2	0	1	0
8	1	1	1	0	1	0
9	3	0	1	0	1	0
10	1	0			1	0
Total	14	3	10	0	14	0

Combined air and ground counts were made on 14–16 June with a separate air count along the Monterey Bay beaches on 17 June. The count on the 17th (48) was added to the air count on the 16th (317) for analysis. Dividing lines between days were chosen to avoid areas with large numbers of otters so that movement from one area to another would be kept to a minimum from one count day to another. Weather conditions during the census were considered fair to good.

RESULTS AND DISCUSSION

Number of otters, not including clinging pups, counted by ground observers, (n_{2i}) and the number counted by both air and ground observers (m_i) were compiled for each subarea, i, for each day of the census (Table 3). Number of otters counted from the air were 341, 482 and 365 (Table 4). Estimated percentages of animals counted by the plane were 69.3%, 69.5% and 61.5% (Table 4). The decline in percentage counted on the last ground truth day could be attributed to increased wind and rougher seas.

TABLE 3. Number of Sea Otters Counted from Shore, n_2, and Number Seen by Air and Ground, m, for 14, 15, and 16, June 1976.

Area	*Day*					
	14 June 76		*15 June 76*		*16 June 76*	
i	n_{2i}	m_i	n_{2i}	m_i	n_{2i}	m_i
1	86	75	9	1	9	7
2	5	3	6	4	8	8
3	2	1	7	7	4	4
4	1	1	4	4	3	1
5	1	0	18	10	16	7
6	1	0	3	3	2	2
7	2	2	10	9	1	0
8	2	0	5	3	3	3
9	12	5	4	4	1	0
10	44	40	1	1	3	1
11	5	1	7	1	2	1
12	4	4	8	8	2	2
13	1	1	6	4	7	3
14	9	4	2	0	20	16
15	9	8	12	11	13	7
16	3	3	23	11	7	4
17	2	2	7	5	3	2
18	2	2	7	4	5	2
19	3	0	11	4	1	1
20	1	0	3	2	7	0
21	3	2	3	1	12	6
22	10	8	7	7	7	5
23	26	16	1	1	32	28
24	6	3	1	0	4	4
25	7	1	2	2	9	4
26	4	2	15	13	3	1
27	5	1	3	2	3	3
28	3	0	7	4	1	1
29	4	0	15	14	1	1
30	5	3	6	1	1	0
31	3	2	1	0	2	1
32	1	1	2	2	2	1
33	2	0	13	12	17	16
34	3	1	16	16	24	12
35			13	9	23	9
36			6	5	20	16
37			16	9	4	1
38			7	5	7	3
39			8	6	7	4
40			15	15	3	1
41			4	4	5	2
42			1	0	1	1
43			1	0	1	1
44			2	0	3	0
45			1	1	7	3
46			6	2	7	3
47			2	1	7	5
48			1	1	3	0
49			1	1	2	0
50			2	1	2	1
51			3	1	19	19
52					6	2
53					1	1
54					4	1
55					2	0
Total	277	192	334	232	369	227

TABLE 4. Sum of Free Swimming Otters Counted by Air, n, by Ground, n, and in Common, m, with 95% C.I. by Number with 95% C.I. by Day for 14, 15, 16 June.

Date	Σn_1	Σn_2	Σm	$\hat{p}$	$\hat{P}_{.95}$ Lower	$\hat{P}_{.95}$ Upper	N	95% Confidence Limits Lower	95% Confidence Limits Upper
14	341	277	192	.693	.638	.749	492	455	534
15	482	334	232	.695	.644	.745	694	646	748
16 *	365	369	227	.615	.564	.666	593	548	647
14–16 *	1188	980	651	.664	.633	.695	1789	1709	1877

* Air Count on 17 June (48) added to count on 16 June (317).

Estimated numbers of otters in each area (95% confidence limits) were 492 (455–534), 694 (646–748), 593 (548–647) (Table 4). Total number of otters was 1789 (1709–1877). Confidence limits were calculated using equation 1.

However because

$$n_1 + n_2 > N$$

variance equation 2 could be used which results in confidence limits about 35% smaller than those calculated from equation 1 (Table 5).

TABLE 5. Number of Sea Otters with 95% Confidence Limits Using Variance Adjusting Sample Size Approaching Population Size.

		95% Confidence Limit	
Date	*N*	*lower*	*upper*
14	492	466	518
15	694	658	730
16	593	564	622
14–16	1789	1734	1844

The estimated percentage of clinging pups seen by aerial observers was only 7.7%. Of 38 clinging pups observed by ground counters, only three were seen from the air and all three were seen on the first day of the census. As a result, the total number of clinging pups could be estimated for the three days combined but not for each day. The estimated number of clinging pups was 165 with the 95% confidence limit going from 80 to an undefined large number. Obviously with such wide confidence limits, the estimated number of clinging pups could be off by a considerable amount. However, 38 clinging pups were counted by ground observers while air observers counted 10 clinging pups in areas with no ground observers. This gives an absolute lower bound of 48 clinging pups. In addition, ground observers counted 980 free-swimming animals out of an estimated 1789 or 54.8% (Table 4). If clinging pups occur in the same proportion in and out of ground truth areas, these ground truth counts would have yielded about 69 clinging pups. This number should be raised to about 80 clinging pups by adjusting for animals missed by ground observers (Table 1).

The goodness of fit of data to this model was tested using chi-squared analysis. The actual number of animals seen by both air and ground observers, m_i, to the expected number based upon the overall ratio for each day were compared. A large chi-squared value would result if the ratio were correlated with time or with the number of animals occuring in ground areas. However in each case, June, 14, 15, and 16 chi-squared values at $p > 0.5$ were greater than calculated values indicating that these data could be applied to this model (Table 6).

TABLE 6. Goodness of Fit by Day for 14, 15, and 16 June 1976

			Chi-square	
Date	*Number of ground stations*	$\hat{P}$	*Calculated*	*P=0.5*
14	34	.693	31.8	32.8
15	51	.695	32.8	49.3
16	55	.615	45.5	54.8

CONCLUSION

Application of methods used in analysis of single mark and recovery studies to sea otter census data gives a simple and straight forward method of estimating total population size and a variance of that estimate.

As in actual mark and recovery experiments, several sources of bias are possible. Population estimates will be low if otters missed from air are more likely to be missed from the ground than those animals seen from the air. An example would be animals that are wrapped in kelp and hidden from view. Such animals would be analogous to individuals in a tagging study that are unavailable to the capture gear being used. Another source of bias could result if a different proportion of otters are seen from the air in and out of ground count areas. In a tagging study, this would be analogous to non-random mixing of marked animals within the population. A final source of error would result from confusion in identifying those animals that are seen in common by air and ground observers. This error would not be encountered in a mark and recapture study. The closest analogy would be tag loss.

All three possible sources of error are unmeasurable. However, an upper limit can be estimated for confusion of animals between air and ground. The only time that an animal seen from the air would be confused with one missed from the air is when ground observers saw the one that was missed from the air but missed the one that had been seen from the air. In addition both animals would have to be in close proximity to each other. In ground truth areas, the total percentage of animals missed by both air and ground observers was 5% (Table 1). Consequently, the number of animals involved in confusion would be considerably less than 5%. Nevertheless, this does indicate the importance of keeping ground areas small enough so that observers can count most, if not all, animals that are not hidden.

Although this model is easily adaptable to concurrent air and ground counts, it could also be applied to two concurrent ground counts if comparisons of the two counts can determine those animals that are seen in common. Obviously accuracy of estimates obtained from this model will be limited by the number of animals that are hidden from both observers and the ability to relate concurrent counts correctly identifying those animals which are seen in common.

LITERATURE CITED

Boolootian, R. A. 1961. The distribution of the California sea otter. Calif. Fish Game, 47(3):287–292.

California Department of Fish and Game. 1976. A proposal for sea otter protection and research, and request for the return of management to the State of California. Appendix F. Unpub. paper. Jan. 1976. 271.

Carlisle, J. G., Jr. 1965. Flight report 65-7—special projects. Calif. Dept. Fish and Game, Mar. Res. Oper. 3p.

Miller, D. J. 1958. Airplane spotting flight 58-6. Calif. Dept. Fish and Game, Mar. Res. Oper. 6p.

________ 1976. Flight report 76-C-2. Calif. Det. Fish and Game, Mar. Res. Oper. 5p.

________ 1980. The sea otter in California. CalCOFI Rep., 21:79–81.

Odemar, M. W. 1969. Flight report 69-C-10 sea otter-abalone. Calif. Dept. Fish and Game, Mar. Res. Oper. 2p.

Samuel, M. D. and K. H. Pollock. 1981. Correction of visibility bias in aerial surveys where animals occur in groups. J. Wildl. Manage. 45(4):993–997.

Seber, G. A. F. 1973. The estimation of animal abundance and related parameters. Griffin Press, London. 506p.

Wild, P. W. 1973. Flight report 73-C-3 sea otter. Calif. Dept. Fish and Game, Mar. Res. Reg. 3p.

Wild, P. W. and J. A. Ames. 1974. A report on the sea otter, *Enhydra lutris* L., in California. Calif. Dept. Fish and Game, Mar. Res. Tech. Rep. 20:1–93.

Wilson, K. C. 1968*a*. Flight report 68-4 sea otter-abalone. Calif. Dept. Fish and Game, Mar. Res. Oper. 2p.

________ 1968*b*. Flight report 68-5 sea otter-abalone. Calif. Dept. Fish and Game, Mar. Res. Oper. 2p.

Calif. Fish and Game 70(4): 234–239 1984

CLEANING BEHAVIOR OF THE JUVENILE PANAMIC SERGEANT MAJOR, *ABUDEFDUF TROSCHELII* (GILL), WITH A RÉSUMÉ OF CLEANING ASSOCIATIONS IN THE GULF OF CALIFORNIA AND ADJACENT WATERS [1]

RICHARD M. McCOURT and DONALD A. THOMSON
Department of Ecology and Evolutionary Biology
University of Arizona
Tucson, Arizona 85721

Cleaning behavior is described for the juvenile Panamic sergeant major, *Abudefduf troschelii* (Gill), in association with larger conspecific hosts and with members of schools of four pelagic host species in the Gulf of California and adjacent waters. Sergeant majors behaved similarly toward the four pelagic host species: halfbeak, *Hyporhamphus* sp.; striped mullet, *Mugil cephalus* Linnaeus; needlefish, *Strongylura* sp.; and wavyline grunt, *Microlepidotus inornatus* Gill. Individual cleaning sequences usually lasted only a few seconds and ended with the host fish darting away after a few nips by the cleaner. Cleaners often ascended a meter or more into the water column to meet hosts that had dropped out of the swimming pattern of their schools. Posing by hosts, if it occurred, was brief and without color change; poses consisted of simple changes in position of the host's body. It is suggested that generalist midwater picker-type fishes such as *A. troschelii* may be particularly suited for cleaning hosts in schools that are transient components of reef communities.

A summary of published and unpublished reports of cleaning activity in the Gulf of California is provided.

The Panamic sergeant major, *Abudefduf troschelii*, has been observed to clean fishes in the Gulf of California (Hobson 1968) and marine iguanas in the Galápagos Islands (Hobson 1969). Nevertheless, little is known of specific cleaning interactions of *A. troschelii* with other species, even though it is perhaps the most abundant reef fish in the Gulf of California. We compare the behaviors of Panamic sergeant majors in cleaning associations with conspecifics and four species of inshore pelagic fishes and summarize published and unpublished observations of cleaning activity among Gulf of California fishes and invertebrates.

We observed members of a school of adult halfbeaks, *Hyporhamphus* sp., being cleaned by a group of juvenile (second-year class) Panamic sergeant majors in July 1976 near Loreto, Baja California Sur, Mexico. The cleaning took place on several successive days in rocky coves, in water 0.5–4.0 m deep. Detailed observations were made on one day in a cove where approximately 200 halfbeaks schooled a meter below the surface. Cleaning continued for 3 hr (1200 to 1500) until the school left the cove and was restricted to areas where sergeant majors hovered near the bottom. Discrete cleaning stations were not identifiable. Not all of the school of halfbeaks engaged in cleaning. Some individuals swam downward from the school as several sergeant majors approached them from below. The halfbeaks would stop swimming and tilt their bodies upward at angles from 30° to 90° for a few seconds (see Thomson, Findley, and Kerstitch 1979, Figure 108). No color changes were observed in the hosts or the cleaners. Hosts posed for only a few seconds regardless of whether or not they were cleaned and the flow of the rest of the school was not disrupted.

[1] Accepted for publication November 1983.

Occasionally halfbeaks posed but were not cleaned or inspected and sergeant majors occasionally nipped at non-posing halfbeaks that would then quickly dart away. Cleaners started their inspections near the head of the host and worked back toward the tail. Within seconds after the inspection began and after only one or two nips by the cleaner, the halfbeak host would jerk away and resume swimming with the school. The cleaner occasionally nipped at the tail of the departing host but more often moved on to another halfbeak or swam back toward the bottom.

Adult striped mullet, *Mugil cephalus,* were observed being cleaned in a shallow cove (less than 2 m) of Playa de las Minitas, ca. 48 km north of Puerto Vallarta, Nayarit, Mexico in June 1977. The mullet were loosely aggregated in a small region where about 10 juvenile Panamic sergeant majors occupied a general cleaning area. Posing mullet assumed a head-down position, their bodies tilted about 45° from horizontal. No color changes were seen. A cleaner started its inspection of a host at the head but most nips were on the host's tail region. Many of the hosts had sores and scars on their bodies suggesting that the cleaners may have been removing necrotic tissue. Like halfbeaks, the mullet twitched when nipped by cleaners and darted a short distance away after only a few seconds of cleaning. In contrast to their usual wariness in non-cleaning situations the mullet seemed very quiescent and could be easily approached by observers.

A school of needlefish, *Strongylura* sp., was seen being cleaned by Panamic sergant majors in the shelter of a breakwater in Mazanillo Bay, Colima, Mexico, in the summer of 1977. Both hosts and cleaners were large juveniles. A distinct cleaning pose was not as evident as the poses of the halfbeaks and mullet, but during cleaning a needlefish would sometimes arch its back with its head and tail raised. The host school maintained an active swimming pattern except for individuals that stopped swimming to be cleaned. Cleaners nipped hosts mostly in the tail region. Like the other hosts, needlefish showed a twitch-and-dart reaction after only a few nips.

These superficial grooming interactions are similar to those reported for the needlefish, *Strongylura fodiator,* host and barberfish, *Johnrandallia* [= *Heniochus*] *nigrirostris,* cleaner in the southern Gulf of California (Hobson 1965). Most of the host species that Hobson (1965) observed had to seek out cleaners at stations among the rocks, but for needlefish the cleaners would leave the bottom and service hosts in midwater or even at the surface. Another pelagic schooling fish, the sierra mackerel, *Scomberomorus sierra,* sometimes descended to the barberfishes' cleaning stations, but only stayed for a short time before rejoining its fast-moving school. The sergeant major, like barberfish, may facilitate cleaning of pelagic hosts by swimming up to meet them in the water column.

A school of wavyline grunts, *Microlepidotus inornatus,* was observed being cleaned by three or four yearling sergeant majors in the summer of 1982. Twelve to fifteen adult grunts schooled in a clear sandy cleaning area surrounded by rocks in 1.5 m of water. Some grunts postured vertically with head down during cleaning; others simply remained motionless. All the grunts displayed normal light coloration while being cleaned, except for the largest individual, which darkened considerbly and erected its dorsal fin. A sergeant major would swim up and inspect the entire host, nipping at areas around the head, trunk, and tail. Occasionally the host would jerk suddenly away after it was nipped.

Several features were common to all of the cleaning interactions between Panamic sergeant majors and their hosts. In each case a group of sub-adult sergeant majors cleaned members of a host school of more or less silvery, elongate, pelagic fishes that are normally transient members of the reef community (Thomson, Findley and Kerstitch 1979). Cleaners often ascended into the water column to meet hosts. Cleaning took place in generalized cleaning areas located within protected coves or breakwaters. Specific cleaning sequences were short (2 or 3 s) and ended with a nip or two on the host's tail region as it jerked away. Posing, if it occurred at all, was brief and usually without color change.

On two occasions during the summer of 1980 juvenile Panamic sergeant majors were seen cleaning a group of larger conspecifics. Both incidents occurred in less than 2 m of water near small islands (Isla Parga and Isla Coyote) in Bahía Concepción, Baja California Sur. At each location one small juvenile cleaned the trunks and caudal peduncles of larger conspecifics, some of which were slightly darkened in color. Several individuals posed at the same time, remaining motionless with their heads tilted slightly downward while the rest of the group hovered in a restricted area near the bottom. Several times territorial Cortez damselfish, *Eupomacentrus rectifraenum,* charged the group and forced it to scatter but it quickly regathered each time.

The cleaning associations of sergeant majors are generally less habitual than those of some tropical cleaner wrasses of the genus *Labroides* in Hawaii (Feder 1966, Losey 1971). They are, however, similar to the cleaning interactions between barberfish and their pelagic hosts in the Gulf of California (Hobson 1965). The tail-down pose of *Hyporhamphus* is similar to the pose displayed by atherinids posing to be cleaned by zebra perch, *Hermosilla azurea,* and opaleye, *Girella nigricans,* in southern California (Hobson 1971, DeMartini and Coyer 1981). These cleaner species feed on a broad diet of benthic and midwater prey and Hobson (1968, 1971) suggested that this may enable them to readily modify their foraging behavior for cleaning. A picker-type forging strategy combined with part-time midwater habits may make such cleaners especially accessible to pelagic schooling species.

Given the abundance of *A. troschelii* on Gulf of California reefs and the relative rarity of cleaning by them it seems likely that either a few individuals clean habitually or else a larger number clean for limited portions of time. This is apparently the general pattern among picker-type species with moderate to large population sizes, such as the señorita, *Oxyjulis californica* (Hobson 1971), rock wrasse, *Halichoeres semicinctus* (Hobson 1976), and opaleye, *Girella nigricans* (DeMartini and Coyer 1981). Although the forging behavior of these species is probably easily adaptable to cleaning behavior, it would seem impossible for the entire population of a locality to make a living by cleaning. Therefore, cleaning by only a small portion of the population at a given time and place might be the only stable cleaning strategy. DeMartini and Coyer (1981) suggested that one benefit of this type of food specialization is that it may allow greater population densities without a marked increase in intraspecific competition.

Like many other cleaner species worldwide (Feder 1966) and in the Gulf of California in particular (Table 1), the juveniles or sub-adults of *A. troschelii* are the only members of the species known to clean. Moreover, smaller juveniles were observed to clean larger conspecifics. This fits the general pattern in cleaning associations, in which cleaners are smaller than and pose little threat to their hosts (Feder 1966).

TABLE 1. Cleaning Associations in the Gulf of California and Adjacent Waters. Sources are: (1) This paper; (2) Thomson *et al.* 1979; (3) Hobson 1965; (4) Hobson 1968; (5) Unpublished field notes of C. Limpbaugh reported in Feder 1966; (6) Reynolds 1977; (7) D. A. Thomson, pers. obs.; (8) A. N. Kerstitch, pers. obs. Taxa used in original source shown in parentheses. Common names mostly from Thomson *et al.* (1979) in parentheses following scientific names. Juveniles indicated by (j); * = host not identified.

Cleaner	*Host*	*Location*	*Source*
FISHES			
Family Pomacentridae (damselfishes)			
Abudefduf troschelii (j) (Panamic sergeant major)	*A. troschelii*	Bahía Concepción, B.C.N.	1
	Hyporhamphus sp. (halfbeak)	Loreto, B.C.S.	1
	Strongylura sp. (needlefish)	Manzanillo Bay, Colima	1
	Mugil cephalus (striped mullet)	Playa de las Minitas, Jalisco	1
	Microleptidotus inornatus (wavyline grunt)	Punta Chicato, B.V.S.	1
	Homo sapiens (human)	Baja California Sur	6
Microspathodon dorsalis (j) (giant damselfish)	*	Guaymas, Sonora	5
	*	Manzanillo, Colima	5
	Holocanthus passer (king angelfish)	home aquarium	7
Family Chaetodontidae (butterfly fishes)			
Johnrandallia nigrirostris (barberfish)	*Selene brevoorti* (= *oerstedi*) (Mexican lookdown)	Southern Gulf	3
	Haemulon sexfasciatum (graybar grunt)	Southern Gulf	3
	Kyphosus elegans (Cortez chub)	Southern Gulf	3
	Scomberomorus sierra (sierra mackerel)	Southern Gulf	3
	Strongylura fodiator (needlefish)	Southern Gulf	3
	Gnathanodon speciosus (yellow jack)	Southern Gulf	3
	Mulloidichthys dentatus (= *M. rathbuni*) (Mexican goatfish)	Southern Gulf	3
	Calamus brachysomus (Pacific porgy)	Guaymas, Sonora	5
	Mycteroperca spp. (seabasses)	Guaymas, Sonora	5
	Epinephelus dermatolepis (= *Dermatolepis punctata*) (leatherbass)	Guaymas, Sonora	5
	*	*Manzanillo, Colima*	*5*
Family Labridae (wrasses)			
Thalassoma lucasanum (j) (Cortez rainbow wrasse)	Kyphosidae (rudderfishes)	Guaymas, Sonora	5
	Prionurus punctatus (yellowtail surgeonfish)	Guaymas, Sonora	5
	Abudefduf troschelii (sergeant major)	Loreto, B.C.S.	7
	Homo sapiens (human)	Baja California Sur	6

TABLE 1. Continued

Thalassoma lutescens (j) (sunset wrasse)	*Epinephelus itajara* (jewfish)	Cabo San Lucas, B.C.S.	8
Bodianus diplotaenia (j) (Mexican hogfish)	*	Guaymas, Sonora	5
Halichoeres nicholsi (j) (spinster wrasse)	*Microspathodon dorsalis* (giant damselfish)	Isla San Pedro Mártir	8
Semicossyphus pulcher (j) (California sheephead)	*Hippocampus ingens* (Pacific seahorse)	Aquarium	8
Family Pomacanthidae (angelfishes)			
Holocanthus passer (j) (king angelfish)	*	Guaymas, Sonora and Manzanillo, Colima	5
Pomacanthus zonipectus (j) (Cortez angelfish)	*Paranthias colonus* (Pacific creole fish)	Cabo San Lucas, B.C.S.	8
	Homo sapiens (human)	Baja California Sur	6
Family Gobiidae (gobies)			
Elacatinus digueti	*Homo sapiens* (human)	Baja California Sur	6
	Gymnothorax castaneus (Panamic green moray)	Southern Gulf	2,8
	Epinephelus itajara (jewfish)	Southern Gulf	2,8
MISCELLANEOUS			
Girella simplicidens (j) (Gulf opaleye)	*Xenistius californiensis* (j) (salema)	Sonoran coast	7
Canthigaster punctatissima (spotted sharpnose puffer)	*Sufflamen verres* (orangeside triggerfish)	Cabo San Lucas, B.C.S.	8
Doryrhamphus melanopleura (fantail pipefish)	*Pomacanthus zonipectus* (j) (Cortez angelfish)	Aquarium	8
Scaridae (parrotfishes)	*	Manzanillo, Colima	5
Eucinostomus sp. (flagfin mojarra)	*Homo sapiens* (human)	Baja California Sur	6
INVERTEBRATES (all crustaceans)			
Palaemon ritteri	*Homo sapiens* (human)	Baja California Sur	6
	Girella simplicidens (Gulf opaleye)	Puerto Peñasco, Sonora	8
Periclimenes lucasi	*Haemulon sexfasciatum* (graybar grunt)	Guaymas, Sonora	8
Gnathophyllum panamense	*Gymnothorax castaneus* (Panamic green moray)	Guaymas, Sonora	8
Lysmata intermedia	*Gymnothorax castaneus* (Panamic green moray)	Guaymas, Sonora	8
L. californica	*Cirrhitus rivulatus* (giant hawkfish)	Guaymas, Sonora	8

Aside from descriptions of the cleaner, *Johnrandallia nigrirostris,* the barberfish (Hobson 1965, 1968), and a note on facultative cleaning behavior by several species of invertebrates and fishes (Reynolds 1977), few details have been published regarding cleaner habits in the Gulf of California. Nevertheless, cleaning is widespread in the Gulf and involves a wide diversity of hosts and cleaners, both vertebrate and invertebrate (Table 1). More cleaning activity has been reported among the more diverse fauna of the central and southern portions of the Gulf, but this may be due in part to a lack of diving observations in the relatively murky waters of the northern Gulf. With the possible exception of the banded cleaner goby, *Elacatinus digueti* (A. Kerstitch, pers. commun.) there are no cleaners in the Gulf of California that clean as habitually as many other tropical species (see Feder 1966). Further observations of cleaning in this unique region should add to an understanding of the nature and biogeography of cleaning associations in general.

ACKNOWLEDGMENTS

We thank E. S. Hobson, E. E. DeMartini, A. Kodric-Brown, and L. Y. Maluf for helpful comments on this manuscript. We are grateful to A. N. Kerstitch for sharing his unpublished observations with us.

LITERATURE CITED

DeMartini, E. E. and J. A. Coyer. 1981. Cleaning and scale-eating in juveniles of the kyphosid fishes, *Hermosilla azurea* and *Girella nigricans*. Copeia, 1981:785–789.

Feder, H. M. 1966. Cleaning symbiosis in the marine environment, P. 327–380. *in*: S. M. Henry, ed. Symbiosis, Vol. 1. Academic Press, New York, 478 p.

Hobson, E. S. 1965. A visit with el barbero. Underwater Naturalist, 3(3):5–10.

———. 1968. Predatory behavior of some shore fishes in the Gulf of California. Res. Rep. U.S. Fish. Wildl. Serv., 73:1–92.

———. 1969. Remarks on aquatic habits of the Galápagos marine iguana, including submergence times, cleaning symbiosis, and the shark threat. Copeia, 1969:401–402.

———. 1971. Cleaning symbiosis among California inshore fishes. U.S. Nat. Mar. Fish, Serv., Fish. Bull., 69(3):491–523.

———. 1976. The rock wrasse, *Halichoeres semicinctus* as a cleaner fish. Calif. Fish Game, 62:73–78.

Losey, G. S., Jr. 1971. Communication between fishes in cleaning symbiosis, P. 45–76. *in:* T. C. Cheng, (ed.) Aspects of the biology of symbiosis. Univ. Park Press, Baltimore, 327 p.

Reynolds, W. W. 1977. Substrate feeders and facultative cleaners: Cleaning behaviour in some Gulf of California marine animals. Anim. Behav., 25:1063.

Thomson, D. A., Findley, L. T., and Kerstitch, A. N. 1979. Reef fishes of the Sea of Cortez. John Wiley and Sons, New York, 302 p.

Calif. Fish and Game 70(4): 240–247 1984

EFFECTS OF CATTLE GRAZING ON SELECTED HABITATS OF SOUTHERN MULE DEER [1]

R. TERRY BOWYER [2]
School of Natural Resources
The University of Michigan
Ann Arbor, MI 48109
And
VERNON C. BLEICH
California Department of Fish and Game
P.O. Box 1741
Hemet, CA 92343

Comparisons of cattle ranges and areas without cattle were made from May–August 1979 in montane regions of San Diego County, California. Spotlight transects found significantly fewer southern mule deer, *Odocoileus hemionus fuliginatus,* in meadows where cattle grazing occurred than in similar areas where cattle were prohibited. Deer pellet groups were found significantly more often on ranges without cattle than on ranges with them. Vegetative sampling indicated that total cover of plants was significantly greater in meadows where cattle were absent. The diet of cattle substantially overlapped that of deer. Three important deer forage species were absent from cattle ranges, and others present exhibited significantly more use than in meadows without cattle. Cattle grazing also may limit deer numbers by reducing dense patches of *Muhlenbergia rigens* used for cover during the fawning period.

INTRODUCTION

The importance of competition between mule deer, *Odocoileus hemionus,* and cattle has been the subject of considerable debate (Urness 1976). Many authors have contended that only slight competition occurred (Stoddart and Rasmussen 1945; Julander 1955; Swank 1958; Skovlin, Edgerton, and Harris 1968), whereas others reported considerable overlap in the diet of these herbivores (Dixon 1934, Martinson 1960, Tueller and Monroe 1975). Overlap in forage preference may be unimportant on lightly-stocked cattle ranges (Leopold *et al.* 1951, Mackie 1970, Dusek 1975), but heavy cattle grazing has the potential to adversely affect deer populations (Longhurst, Leopold, and Dasman 1952; Mackie 1981). However, as Mackie (1976) noted, quantitative data necessary to assess the effects of competition between cattle and deer often are lacking.

Subjective observations made along roadways from 1977–1979 and during a helicopter flight in spring 1979 revealed a conspicuous absence of nonmigratory southern mule deer, *O. h. fuhginatusi,* on cattle ranges in montane San Diego County, California, but deer were plentiful on nearby areas without cattle. Thus, a quantitative investigation of similar deer and cattle ranges was undertaken during late spring to mid-summer (May–Aug.) to test for differences in forage utilization on these areas and to compare the number of deer found on each type of range.

STUDY AREA

Four natural meadows in the Laguna and Cuyamaca Mountains were selected

[1] Accepted for publication February 1984

[2] Mr. Bowyer's present address: Center of Environmental Sciences, Unity College, Unity, Maine 04988.

as typical cattle ranges. Seven similar meadows within Cuyamaca Rancho State Park were chosen as representative areas without cattle. Two meadow systems where cattle were pastured adjoined Park land, and none were more than 20 km from the Park. Elevations of the meadows ranged from 1400–1670 m. Soils were alluvial sandy loams derived from schist parent materials (Oberbauer 1978). The mean annual temperature at 1418 m in the Park was 12°C; annual precipitation averaged 88 cm (Bowyer 1981).

Meadows were characterized by annual grasses and forbs, including *Bromus tectorum, B. diandrus, Avena barbata, Festuca octoflora, Erodium cicutarium, Ambrosia psilostachya,* and *Eriogonum gracile.* Oberbauer (1978) and Bowyer and Bleich (1980) provide a more complete description of meadows and surrounding vegetative types of this area. Longhurst *et al.* (1952) rated cattle ranges in this area as "overgrazed," and based on vegetative and soil conditions we rated them as poor. Public hunting was prohibited on all areas, but some cattle ranges may have been hunted by private landowners.

METHODS

Standardized spotlight transects (Progulske and Duerre 1964, McCullough 1982) were conducted from sundown to 0100 hours PST during June–August 1979 on cattle ranges and similar areas without cattle to determine deer use. The time at which a given meadow was spotlighted was rotated with each sampling effort to help neutralize the influence of temporal changes in deer and cattle activity patterns on estimates of animal abundance.

A modification of the step-point method (Evens and Love 1957) was used to sample percent cover and percent relative frequency of meadow vegetation during June 1979. Starting points were selected using a random numbers table and grid; initial direction of travel was determined by flipping a coin twice, and transects were aligned with a compass. The distance between step-points was five paces (approximately 4 m), and transects were located 20 paces (approximately 16 m) apart. Biases from foot placement were avoided by having samplers keep their eyes on the horizon and not look downward until their foot was in place for each sample. Personal errors in point sampling are only important in tall vegetation (Kershaw 1964). This problem was not important on our study areas because forbs and grasses were typically low-growing. To reduce sampling time, a line drawn on the toe of a boot was used in place of a pin. One drawback to point sampling is that estimates of abundance are exaggerated as pin diameter is increased (Kershaw 1964). We minimized this bias by using a thin line (< 1 mm). Percent cover was determined by noticing the first portion of a plant "hit" by this thin line on the boot. Frequency was tabulated only for those "hits" that struck the base of herbaceous plants. Where absolute measures of cover are required, an optical cross-wire apparatus must be used (Kershaw 1964). However, as long as size is held constant, small points provide reliable estimates of abundance for comparisons between areas (Kershaw 1964).

Deer and cattle utilization of meadow vegetation was determined by estimating the amount of forage available on a given plant and noting the actual number of "bites" already removed (Mackie 1970). Wallmo *et al.* (1979) found that hand-plucked samples of simulated "bites" varied little from relative intake based on measurements of bites removed by feeding deer. Each plant "hit" by a step-point was examined for animal use, thereby providing an estimate of the

percent of total plants utilized as well as the percent of each plant removed. The only forage species counted were those that showed utilization by cattle and deer. Those not used were designated "other species".

Wallmo *et al.* (1973) reported that feeding-site inspections did not produce appreciably different estimates from bites removed by grazing deer for frequently occurring forage species, but that the use of less common plants was estimated poorly. They also suggested the most important source of error in their sampling was the inability to distribute their feeding-site sample plots in a proper relationship to the distribution of deer grazing. This may have occurred because samplers followed arbitrarily chosen deer trails within an enclosure and located a 30 × 30 cm plot at three pace intervals. This design clearly will not provide random samples and, by their own admission, inadequate sample sizes probably resulted in errors for some species. A major source of error in their data came from rare shrubs with uneven distributions. Another factor not discussed was the selection of quadrat size, which is known to have a profound influence on frequency data (Kershaw 1964).

Fortunately, herbaceous meadow vegetation on our study areas exhibited a relatively even distribution when compared with shrubs that resulted in errors in other data sets (Wallmo *et al.* 1973). Samples were collected only in mesic portions of meadows. We overcame problems of distribution by randomized sampling, and errors associated with quadrat size were avoided by plotless step-point samples. Adequate sample sizes were insured for forage species in each meadow by stabilizing their means (Kershaw 1964).

It was not possible to distinguish between grazing by cattle and deer on cattle ranges. However, deer occurred on these ranges so infrequently that this source of error was minimal. Although our estimates of forage removal by deer and cattle may vary from actual amounts removed by grazing animals, they do provide a standardized methodology for a relative comparison of different ranges.

Forage preference ratings were calculated in the manner described by Petrides (1975). Additionally, a record of the number of deer pellet groups encountered during vegetation sampling was used as a relative index to the abundance of deer. A two-sample Z-test for proportions was used to compare frequency data, and a t-test was used for comparing means (Remington and Schork 1970).

RESULTS

One hundred seventy one ha of cattle range from four meadow systems and 233 ha from seven meadows without cattle were spotlighted between four and six times each. Three deer and 166 cattle were found on cattle ranges, whereas 212 deer were tallied during spotlight counts of meadows where cattle were prohibited. Mean densities of two deer (SD = 1, range = 0–12) and 97 cattle (SD = 69, range = 0–684) per 100 ha were found for cattle ranges, while a mean of 22 deer (SD = 10, range = 0–217) per 100 ha occurred on areas without cattle. A significant difference existed between the mean number of deer in meadows where cattle grazing was permitted and meadows where it was not ($t = 8.89$, $P < 0.001$, 53 d.f.). Deer pellet groups were significantly less frequent ($Z = 14.04$, $P < 0.001$, 1 d.f.) on cattle ranges ($N = 3$) than on areas without cattle ($N = 205$).

Twelve hundred sixty three plants were examined for signs of utilization on

cattle ranges, and 2434 plants were inspected on meadows without cattle. Either percent cover or percent relative frequency for deer forage species was significantly lower on cattle ranges than on meadows where cattle were absent (Table 1). Summations of percent cover ($Z = 11.88$, $P < 0.001$, 1 d.f.) and percent relative frequency ($Z = 15.36$, $P < 0.001$, 1 d.f.) of deer forage species were significantly greater on areas without cattle. Additionally, total percent cover and frequency were lower on cattle ranges than on areas without cattle (Table 1). A 50% overlap occurred in the plant species utilized by deer and cattle in meadows. Three forbs important in the diet of deer (*Gilia caruifolia, Lactuca serriola,* and *Sisymbrium altissimum*) were absent from cattle ranges and may have been eliminated by grazing. If this was the case, the diet of cattle overlapped that of deer by 100%. Additionally, a significantly greater percentage of all *Erodium cicutarium,* an important forage species for both deer and cattle, and a larger proportion of each plant were utilized on cattle ranges than on areas without cattle (Table 1).

TABLE 1. Percent Cover, Relative Frequency, and Utilization of Forage Plants in Mountain Meadows With and Without Cattle in San Diego County, California, June, 1979. S = P <.05 (Z–test).

	Percent cover			*Percent relative frequency*			*Percent of each species showing utilization*			*Percent of each plant utilized*		
Deer Forage Species	*With cattle*	*Without cattle*	*P*	*With cattle*	*Without cattle*	*P*	*With cattle*	*Without cattle*	*P*	*With cattle*	*Without cattle*	*P*
Bromus tectorum	9.7	19.7	S	1.0	7.6	S	1.1	0.2		35.7	<0.1	S
Corethrogyne filaginifolia	0.6	1.7	S	0.2	1.0	S	6.7	1.2		33.3	15.0	
Erodium cicutarium	6.3	6.8		0.7	2.7	S	32.4	14.9	S	43.3	21.2	S
Gilia caruifolia	0.0	0.3	S	0.0	0.1		0.0	18.2		0.0	58.3	S
Lactuca serriola	0.0	0.5	S	0.0	0.2	S	0.0	4.8		0.0	8.3	
Sisymbrium altissimum	0.0	2.2	S	0.0	0.8	S	0.0	39.6	S	0.0	47.6	S
Subtotal	16.62	31.2		1.9	12.4							
Cattle Forage Species												
Astragalus sp.	0.8	<0.1	S	0.1	<0.1		12.5			40.0		S
Carex sp.	1.2	1.2		0.3	0.3		24.0		S	57.0		S
Ranunculus sp.	0.5	0.0	S	<0.1	0.0		11.1			11.8		
Sidalcea malvaeflora	1.6	0.2	S	<0.1	0.1		32.1		S	25.7		S
Subtotal	4.1	1.4		0.6	0.5							
Other Species	52.4	47.8		24.3	24.0							
No Vegetation	26.9	19.5	S	73.2	63.1							
Total........................	100.0	100.0		100.0	100.0							
N	1728	3024		1728	3024		1263	2434		1263	2434	

Some variation in cover and frequency of forage species between areas with and without cattle may be a function of site factors rather than cattle grazing. However, results of vegetative sampling from a single meadow, divided into grazed and ungrazed portions by a 4-strand fence (Table 2), showed that the same three species important as forage for deer were absent from cattle range, and that the cover and relative frequency of *Bromus tectorum* and *E. cicutarium* were significantly lower on cattle range than on areas without cattle. Additionally, deer pellet groups occurred more frequently on the portion of this meadow

without cattle than on the portion where cattle grazing was permitted (Z = 4.38, P<0.001, 1 d.f.).

TABLE 2. Differences in Composition of Deer Forage Species on the Same Meadow Divided into Areas With and Without Cattle by a Fence, San Diego, County, California, June 1979. S = P<.05 (Z–test).

	Percent cover			Percent relative Frequency		
Plant species	*With Cattle*	*Without Cattle*	*P*	*With Cattle*	*Without Cattle*	*P*
Bromus tectorum	6.0	22.0	S	0.9	5.8	S
Corethrogyne filaginifolia	1.9	0.9		0.9	0.9	
Erodium cicutarium	0.5	7.2	S	<0.1	2.1	S
Gilia caruifolia	0.0	1.6	S	0.0	0.2	
Lactuca serriola	0.0	0.9	S	0.0	0.5	
Sisymbrium altissimum	0.0	2.2	S	0.0	0.8	
Other Species	61.0	37.2	S	21.6	14.5	S
No Vegetation	30.6	28.0		76.6	75.2	
N	432	432		432	432	

Quantitative ratings of forage preference and importance (Table 3) indicated *Carex* sp. received the highest preference rating for cattle while *G. caruifolia* and *S. altissimum* were highly preferred by deer. Species with preference ratings above 1.00 were those sought by deer or cattle as forage; those with ratings below 1.00 were avoided (Petrides 1975). *S. altissimum* and *E. cicutarium* received high importance ratings for deer in areas without cattle, whereas *E. cicutarium, Carex* sp., and *Sidalcea malvaeflora* were the most important forage species on cattle range. The absence of *S. altissimum* from cattle ranges, combined with the heavy use of *E. cicutarium* on these areas, may explain the low use of cattle ranges by deer.

DISCUSSION

Extremely low densities of southern mule deer on ranges where cattle were pastured in spring and summer, and an abundance of deer on similar ranges without cattle, suggest that cattle use of mountain meadows may limit deer numbers. One explanation of this phenomenon is that cattle grazing reduced or eliminated important forage species for deer. The absence of three forbs preferred by deer, and heavy utilization of *E. cicutarium* on cattle ranges, support this contention (Tables 1–3).

Although mule deer often are thought of as browsers, they require succulent forage for optimum growth and productivity, especially during spring (Short 1981). Visual evidence of heavy cattle grazing on succulents in meadows and riparian zones is apparent throughout the Laguna and Cuyamaca mountains. The same observation was made over 30 years ago (Longhurst *et al.* 1952).

Cattle may limit deer populations by means other than direct competition for food. Photographs documenting cattle grazing in Cuyamaca Rancho State Park in the mid-1950's indicated that stands of *Muhlenbergia rigens,* used by deer for concealment were badly damaged, but recovered once cattle were removed and further cattle use prohibited (Bowyer and Bleich 1980). Parturient does and newborn fawns were found consistently in and around tall (1–1.5 m) stands of *M. rigens* during June and July (Bowyer and Bleich 1980). Dense stands of *M.*

TABLE 3. Utilization, Preference Rating, and Importance Rating for Forage Plants in Mountain Meadows With and Without Cattle, San Diego County, California, June 1979.

	Cattle ranges					Ranges without cattle				
Plant species	*% of species removed* [1]	*% of each species removed as related to all species removed*	*% of each species available as related to all species available* [2]	*Preference rating* [3]	*Importance rating* [4]	*% of species removed* [1]	*% of each species removed as related to all species removed*	*% of each species available as related to all species available* [2]	*Preference rating* [3]	*Importance rating* [4]
Astragalus sp.	5.00	10.9	3.9	2.79	4.00	0.00	0.0	0.02	0.00	0.00
Bromus tectorum	0.39	0.9	46.9	0.02	3.78	0.03	0.1	60.42	0.01	0.59
Carex sp.	13.68	30.0	5.8	5.17	16.63	0.00	0.0	3.68	0.00	0.00
Corethrogyne filaginifolia	2.23	4.9	2.9	1.69	1.34	0.18	0.6	5.21	0.12	0.31
Erodium cicutarium	14.81	32.4	30.4	1.07	93.30	3.16	9.5	20.86	0.46	21.49
Gilia carufolia	–	–	–	–	–	10.61	31.9	0.92	34.67	3.18
Lactuca serriola	–	–	–	–	–	0.40	1.2	1.53	0.78	0.20
Ranunculus sp.	1.31	2.9	2.4	1.21	0.66	–	–	–	–	–
Sidalcea malvaeflora	8.25	18.0	7.7	2.34	0.66	–	–	–	–	–
Sisymbrium altissimum	–	–	–	–	–	18.85	56.7	6.75	8.40	41.47

[1] % of species removed = % of each species showing utilization X proportion of each plant utilized (from Table 1).
[2] Available = % cover (from Table 1).
[3] Preference Rating = % of each species removed as related to all species removed/% of each species available as related to all species available.
[4] Importance Rating = % of species removed × % cover.

rigens found within Cuyamaca Rancho State Park are absent from cattl in the Laguna and Cuyamaca mountains, and we contend that cattle probably eliminated valuable cover for does with fawns. Holl (1976) su that an absence of suitable cover on key summer ranges resulted in in predation of neonate fawns which may have suppressed recruitment ir of California mule deer, *O. h. californicus*. Salwasser, Holl, and Ashcraft hypothesized that although coyotes, *Canis latrans,* were the principal death for fawns in the North Kings herd, the effect of predation on d intensified by factors related primarily to habitat quality. Stocking l livestock also are known to influence deer productivity. McKean and B (1971) and Mackie (1976) reported that fawn mortality was significantl on heavily grazed pastures than on those receiving moderate use.

We never observed deer and cattle together. Deer are thought to avoid cattle in some areas (Mackie 1981), but the role of social interac effecting the near absence of deer on cattle ranges in San Diego C uncertain. Current cattle stocking rates, which contribute to the rem important forage and cover plants for deer, may be sufficient to explain deer use of cattle range in these mountain meadows. Although reliable i tion on the number of cattle using meadows was unavailable, cattle r recorded in spotlight counts apparently were high enough to limit dee cattle range.

Whatever the cause, southern mule deer occurred in comparative numbers on cattle ranges while they were abundant on nearby areas cattle. Clearly, more research is needed to develop livestock manageme tices that will alleviate the adverse effects of cattle on deer and their habi is a critical necessity for the successful management of southern mule large amounts of public land are leased for cattle grazing in San Diego

ACKNOWLEDGMENTS

This study was supported in part by U.S.D.A. Forest Service Cont 9AD6-9-622, the California Department of Parks and Recreation, Sigma Federal Aid in Wildlife Restoration Project W-26-D (California).

M. Cox, S. Wexler, B. Vaughn, M. Curto, R. Rabb, D. Consoli, F. B H. McKinnie assisted with vegetation sampling. W. Robinson, W. Powe Holman helped with the spotlighting transects. We thank J. Geary for permission to conduct research in Cuyamaca Rancho State Park. S. Wehausen, C. Edon, T. Mansfield, and R. Barry reviewed the manusc offered many helpful suggestions.

LITERATURE CITED

Bowyer, R.T. 1981. Management guidelines for improving southern mule deer habitat on the Lagu Demonstration Area. U.S.D.A. For. Serv. 40-9AD6-9-622. 80 pp.

———, and V. C. Bleich. 1980. Ecological relationships between southern mule deer and California Pages 292–296 *in* T. R. Plumb Tech. Coord., Symp. Ecol., Manage., and Util. of California oaks. U Tech. Rep. PSW-44. 368 pp.

Dixon, J.S. 1934. A study of the life history and food habits of deer in California. Calif. Fish Game, 2 315–354.

Dusek, G.L. 1975. Range relations of mule deer and cattle in prairie habitat. J. Wildl. Manage., 39:6(

Evens, R.A. and R.M. Love. 1957. The step-point method of sampling—a practical tool in range man Range Manage., 10:208–212.

Holl, S.A. 1976. North Kings deer herd fawn production and survival study. Calif. Fish Game, Pı W-51-R-20. 71 pp.

Julander, O. 1955. Deer and cattle range relations in Utah. For. Sci., 1:130–139.

Kershaw, K.A. 1964. Quantitative and dynamic ecology. Edward Arnold, London. 183 pp.

Leopold, A.S., T. Riney, R. McCain, and L. Tevis, Jr. 1951. The Jawbone deer herd. Calif. Fish Game, Game Bull., 4:1–139.

Longhurst, W.M., A.S. Leopold, and R.F. Dasmann. 1952. A survey of California deer herds, their ranges and management problems. Calif. Fish Game, Game Bull., 6:1–136.

Mackie, R.J. 1970. Range ecology and relations of mule deer, elk, and cattle in the Missouri River Breaks, Montana. Wildl. Monogr., 20:1–79.

________. 1976. Interspecific competition between mule deer, other game animals and livestock. Pages 49–54 *in* G.W. Workman and J.B. Low, eds., Symp. Mule Deer Decline in the West. Utah State Univ., Logan. 134 pp.

________. 1981. Interspecific relationships. Pages 487–507 *in* O.C. Wallmo, ed., Mule and Black-tailed Deer of North America. Univ. Nebr. Press, Lincoln. 605 pp.

Martinsen, C.F. 1960. The effects of summer utilization of bitterbrush in north central Washington. Unpubl. Thesis. Univ. Idaho, Moscow. 69 pp.

McCullough, D.R. 1982. Evaluation of night spotlighting as a deer study technique. J. Wildl. Manage., 46:963–973.

McKean, W.T. and R.M. Bartmann. 1971. Deer-livestock relations on a pinion-juniper range in northwestern Colorado. P.R. Proj. W-101-R. Colo. Game, Fish and Parks Dept. 132 pp.

Oberbauer, T.A. 1978. Distribution and dynamics of San Diego County grasslands. Unpubl. Thesis, San Diego State Univ. San Diego, CA. 120 pp.

Petrides, G.A. 1975. Principal foods versus preferred foods and their relations to stocking rate and range condition. Biol. Conserv., 7:161–169.

Progulske, D.R., and D.C. Duerre. 1964. Factors influencing spotlighting counts of deer. J. Wildl. Manage., 28:27–34.

Remington, R.D., and M.A. Schork. 1970. Statistics with applications to the biological and health sciences. Prentice-Hall, Englewood Cliffs, NJ. 418 pp.

Salwasser, H., S.A. Holl, and G.A. Ashcraft. 1978. Fawn production and survival in North Kings River deer herd. Calif. Fish Game, 64:38–52.

Short, H.L. 1981. Nutrition and metabolism. Pages 99–127 *in* O.C. Wallmo, ed., Mule and Black-tailed Deer of North America. Univ. Nebr. Press, Lincoln. 605 pp.

Skovlin, J.M., P.J. Edgerton, and R.W. Harris. 1968. The influence of cattle management on deer and elk. Trans. N. Am. Wildl. Nat. Resour. Conf., 33:169–181.

Stoddart, L.A. and D.I. Rasmussen. 1945. Big game-range livestock competition on western ranges. Trans. N. Am. Wildl. Nat. Resour. Conf., 10:251–256.

Swank, W.G. 1958. Mule deer in Arizona chaparral. Ariz. Game and Fish Dept., Wildl. Bull., 3:1–109.

Tuller, P.T., and L.A. Monroe. 1975. Management guidelines for selected deer habits in Nevada. Univ. Nev. Agric. Exp. Sta. Publ. R104. 185 pp.

Urness, P.J. 1976. Mule deer habitat changes resulting from livestock practices. Pages 21–35 *in* G.W. Workman and J.B. Low, eds., Symp. Mule Deer Decline in the West. Utah State Univ., Logan. 134 pp.

Wallmo, O.C., R.B. Gill, L.H. Carpenter, and D.W. Reichert. 1973. Accuracy of field estimates of deer food habits. J. Wildl. Manage., 37:556–562.

Calif. Fish and Game 70(4): 248–251

NOTES

MORTALITY IN CALIFORNIA MULE DEER AT A DRYING RESERVOIR: THE PROBLEM OF SILTATION AT WATER CATCHMENTS

During a 5-day period beginning 24 August 1981, two adult female California mule deer, *Odocoileus hemionus californicus,* and one fawn were discovered entrapped in mud (24, 25, 28 August, respectively) while apparently attempting to drink from a small drying reservoir on Santa Catalina Island, California. Both does were lying on their sides (Figure 1), and were near death when examined. A circular pattern of disturbance in the mud around these animals revealed that they had struggled intensively in an attempt to free themselves. They were capable of only slight head and body movements when prodded, and made feeble attempts to vocalize. The fawn was found dead, lying in a similar position as the does, but its head was totally immersed in the mud.

FIGURE 1. Adult doe trapped in mud on the fringe of a reservoir on Santa Catalina Island, California, 25 August 1981.

The climate of Santa Catalina Island is classified as Mediterranean, characterized by hot, dry summers and mild, damp winters (Trewartha and Horn 1980); rainfall averages approximately 31 cm/yr (Dunkle 1950).

A number of seasonal water sources were available for use by deer on Catalina until early summer, when they began to dry. Water then became limiting, and deer actively sought scattered seeps and man-made reservoirs to meet water requirements. The particular reservoir where the deer became trapped provided the only water source in an area of approximately 5 km^2. Extensive siltation had occurred in the 20 years since it was constructed. Deer of both sexes and all age classes were observed at this reservoir during July and August 1981.

Free water is important for maintaining a favorable water balance in mule deer occupying hot, arid habitats (Short 1981). This demand for free water appears to be a function of both ambient temperature (Longhurst *et al.* 1970) and moisture content of the available forage (Verme and Ullrey 1972). In areas where water is scarce or poorly distributed, range use by mule deer decreases with increasing distance from water (Wood *et al.* 1970), and drought, as a function of the relation between water availability and forage quality, can lead to declines in local deer populations (Anthony 1976).

The construction of water catchments is a common management tool used to improve habitat quality for wildlife on arid ranges. Wood *et al.* (1970) documented that substantial increases in mule deer population density occurred with water development. When water development involves the construction of earth dam tanks or reservoirs in areas where siltation is a problem, it should be recognized that a potential hazard exists for wildlife, as was graphically demonstrated by these observations on Santa Catalina Island. Periodic removal of accumulated silt deposits would rectify the problem and recharge the holding capacity of these catchments.

ACKNOWLEDGMENTS

I thank B. E. Coblentz, R. G. Anthony, D. M. Leslie, Jr., and W. P. Smith for their reviews of the initial draft of this manuscript. This is Oregon Agricultural Experiment Station Technical Paper No. 6253.

LITERATURE CITED

Anthony, R. G. 1976. Influence of drought on diet and numbers of desert deer. J. Wildl. Manage., 40:140-144.

Dunkle, M.B. 1950. Plant Ecology of the Channel Islands of California. Allen Hancock Pacific Expedition., 13:247-386.

Longhurst, W. M., N. F. Baker, G. E. Connolly, and R. A. Fisk. 1970. Total body water and water turnover in sheep and deer. Am. J. Vet. Res., 31:672-677.

Short, H. L. 1981. Nutrition and metabolism. Pages 99–127 *in* O. C. Wallmo, ed., Mule and blacktailed deer of North America. Univ. of Nebraska Press, Lincoln, NE. 605pp.

Trewartha, G. T. and L. H. Horn. 1980. An introduction to climate. McGraw-Hill Book Co., New York, NY. 416pp.

Verme, L. J. and D. E. Ullrey. 1972. Feeding and nutrition in deer. Pages 279–291 *in* D. C. Church, ed., Digestive physiology and nutrition of ruminants, Vol. 3. Practical nutrition. Oregon State Univ., Corvallis, OR. 350pp.

Wood, J. E., T. S. Bickle, W. Evans, J. C. Germany, and V. W. Howard, Jr. 1970. The Fort Stanton mule deer herd (some ecological and life history characteristics with special emphasis on the use of water). New Mexico State Univ. Agric. Exp. Stn. Bull. 567. 32 pp.

—Daniel W. Baber, Department of Fisheries and Wildlife, Oregon State University, Corvallis, Or 97331. *Accepted for Publication July 1983.*

RECORDS OF GOOSEFISHES (FAMILY: LOPHIIDAE, GENUS *LOPHIODES*) FROM CALIFORNIAN WATERS

The family Lophiidae, comprised of four genera, has a worldwide marine distribution occurring in all but Antarctic seas (Caruso 1981). Only two species of the genus *Lophiodes, L. caulinaris* (Garman) and *L. spilurus* (Garman), occur in the eastern Pacific Ocean. *Lophiodes spilurus* is known from California from a single specimen trawled in "the vicinity of Santa Barbara" in 1958 and discussed under the nomen *Chirolophius spilurus* by Fitch and Lavenberg (1968 p. 122). This specimen is also the basis for inclusion of the species in the Hubbs, Follett, and Dempster (1979) "List of the fishes of California" (Lillian J. Dempster, Calif. Acad. Sci., pers. commun.). The aforementioned specimen, actually collected along the edge of Hueneme Canyon (ca. lat 34°05′ N), from 130 fm, on 9 July 1958, is accessioned at Scripps Institution of Oceanography, SIO 58-220, and measures 294 mm TL.

On 24 April 1979, a lophiid, 247 mm TL, was taken off Morro Bay by the F/V RESTLESS C II, a rockfish trawler, from 80 fm and subsequently identified by Lehtonen as *Lophiodes caulinaris.* This represents the first documented capture of the species from Californian waters. The specimen is deposited in the Natural History Museum of Los Angeles County, LACM 38460-1.

On 10 February 1983, a large goosefish, 354 mm TL, was trawled by the F/V NEW MISS ENEZ 13 nautical miles SW of Santa Cruz (ca. lat 36°48′ N, long 122°12′ W), between 260–330 fm; the vessel was fishing over sandy bottom for Dover sole, *Microstomus pacificus.* We identified this specimen as the second California record of *L. spilurus;* it is now deposited at the Natural History Museum of Los Angeles County, LACM 43535-1.

The distribution of *Lophiodes* in the eastern Pacific is primarily tropical (Caruso 1981). It is of interest that the two most recent California captures of *Lophiodes* are from north of Point Conception (lat 34°27′N), a well-known faunal boundary.

Relevant character states and morphometry are included in Table 1 for the three Californian specimens.

TABLE 1. Character States and Measurements for *Lophiodes* from California (Terminology and methods follow Caruso 1981).

	L. spilurus				*L. caulinaris*	
CHARACTER STATE	SIO 58-220		LACM 43535-1		LACM 38460-1	
Pectoral fin ray (L/R)	17/18		16/17		18/18	
Caudal spotting	absent		absent		6 L, 5 R	
Esca	simple		damaged		damaged; esca missing	
Third dorsal spine (DS3)	w/o tendrils		w/o tendrils		w/tendrils	
MEASUREMENT in mm (percent SL)						
Standard length	205.6		257.8		178.4	
Head length	75.1	(36.5)	103.9	(40.3)	65.5	(36.7)
Tail length	67.7	(32.9)	73.7	(28.6)	55.4	(31.1)
Total length	294	(143.0)	354	(137.3)	247	(138.5)
First dorsal spine (IL)	59.1	(28.7)	75.9	(29.4)	34.8	(19.5)
Second dorsal spine (DS2)	47.5	(23.1)	58.4	(22.7)	38.9	(21.8)
Third dorsal spine (DS3)	61.4	(29.9)	64.4	(25.0)	47.7	(26.7)

ACKNOWLEDGMENTS

We would like to thank the skippers and crews for saving fishes in the interest of science: H. Durrah who saved the first California *Lophiodes*, O. Blodgett of the RESTLESS C II, and D. Rappe of the NEW MISS ENEZ.

R. H. Rosenblatt, Scripps Institution of Oceanography, furnished information on and made available the "first California specimen" of *L. spilurus*. R. J. Lavenberg, Natural History Museum of Los Angeles County, checked for additional California records and other eastern Pacific material. T. Iwamoto, California Academy of Sciences, provided comparative material.

We also thank R. H. Rosenblatt, SIO, and J. H. Caruso, Audubon Park and Zoological Garden, for their constructive reviews of this paper.

G. McCoy typed several versions of the manuscript.

LITERATURE CITED

Caruso, J.H. 1981. The systematics and distribution of the lophiid anglerfishes: I. A revision of the genus *Lophiodes* with the description of two new species. Copeia, 1981 (3): 522–549.

Fitch, J.E. and R.J. Lavenberg. 1968. Deep-water teleostean fishes of California. Univ. Calif. Press, Berkeley, 155 p.

Hubbs, C.L., W.I. Follett, and L.J. Dempster. 1979. List of the fishes of California. Occas. Pap. Calif. Acad. Sci., No. 133. 51p.

—Robert N. Lea, California Department of Fish and Game, Marine Resources Branch, 2201 Garden Road, Monterey, California 93940. Thomas Keating and Gilbert Van Dykhuizen, Moss Landing Marine Laboratories, P.O. Box 223, Moss Landing, California 95039, and Philip B. Lehtonen, California Department of Fish and Game, Marine Resources Region, 213 Beach Street, Morro Bay, California 93442. *Accepted for publication August 1983.*

BOOK REVIEW

Worldwide Furbearer Conference Proceedings

Edited by Joseph A. Chapman and Duane Pursley; Worldwide Furbearer Conference, Inc., Book Distribution Center, 1111 East Cold Spring Lane, Baltimore Maryland 21239; 1981; 2056 pp; $60.00

These three volumes contain the papers presented at the Worldwide Furbearer Conference held 3–11 August 1980 in Frostburg, Maryland. These proceedings represent a comprehensive treatment of all aspects of furbearer research and management. The conference included 14 sessions with 110 papers presented during its nine days. The sessions ranged in topics from systematics, zoo-geography and evolution through behavior and concluding with man's impacts on furbearers in the form of depredation control and harvest. Papers were presented by researchers from Europe, Africa, Australia and North America. Over 20 countries were represented. Regardless of the country, the conference contributors clearly demonstrated a worldwide concern for furbearers and a desire to increase men's knowledge of all facets of furbearer biology. Whether it was the biologist from Turkey describing the status of Turkish furbearers, or the researcher from California discussing the usefulness of chemicals to attract or repel coyotes, this general theme was carried throughout this document.

These three volumes were extremely well-edited. The entire work is an excellent example of how the proceedings of a scientific conference should be assembled. Photographs were well chosen and tables concise and informative. Many papers contained extensive listings of cited literature that will further guide the reader who wishes to seek further information about a specific aspect of furbearer biology. This level of excellence was consistent throughout this extensive work and is a tribute to the contributors as well as the editing staff.

Three papers were chosen from the proceedings to provide examples of the extensive treatment of furbearer biology in this work. Serious researchers will appreciate papers such as "Host-Parasite Relationships in Wild Canidae of North America I" presented by J. W. Custer and Danny B. Pence which describes in detail the ecology of helminth infections in the genus *Canis*.

Wildlife managers can choose from a number of informative presentations to assist them in their missions. An example of such a paper is the "Practicality of Reducing a Beaver Population Through the Release of Alligators" by Dale H. Arner, Carl Mason and Carroll J. Perkins. While this technique may be restricted to wildlife managers in areas such as Mississippi, managers in the western U. S. with beaver depredation problems can at least envy them. Wildlife agency policymakers can benefit from the paper "Trappers and Trapping in American Society" by Stephen R. Kellert. The information in this presentation is important to maintaining trapping as a legitimate use of the furbearer resource. While this information may not convince active anti-trappers/anti-hunters, it will influence people not already strongly committed on this issue and help reduce trapping and hunting abuses.

In summary, these proceedings will be a welcome addition to the library of any scientist studying furbearers, biologists managing furbearers, or policymakers who must make decisions regarding furbearer management.—*Frank Wernette*

AUTHORS

SUBJECT

SCIENTIFIC NAMES

Photoelectronic composition by
CALIFORNIA OFFICE OF STATE PRINTING

78742—800 6-84 3,500 LDA

800007

POSTMASTER: RETURN POSTAGE GUARANTEED
Editor, CALIFORNIA FISH AND GAME
CALIFORNIA DEPARTMENT OF FISH AND GAME
1416 NINTH ST., SACRAMENTO, CA 95814